[illegible]
[illegible] & CO.
INDIANAPOLIS, IND.

LIBRARY OF
ELI LILLY & CO.
GREENFIELD, IND.

DATE

Digitized by the Internet Archive
in 2012 with funding from
LYRASIS Members and Sloan Foundation

http://archive.org/details/proceedingsofin451935indi

PROCEEDINGS

of the

Indiana Academy of Science

Founded December 29, 1885

VOLUME 45

PAUL WEATHERWAX, Editor

Field Meeting held at
Mt. Vernon
May 10-11, 1935

Fifty-first Annual Meeting
Wabash College, Crawfordsville
November 7-9, 1935

FORT WAYNE:
FORT WAYNE PRINTING CO., CONTRACTOR FOR STATE PRINTING AND BINDING
1936

Copies of the Proceedings may be purchased through the secretary of the Academy at $3.00 per volume

TABLE OF CONTENTS

Page

Officers and committees for 1935 5
Minutes of Council Meeting 8
Minutes of the Spring Meeting 8
Program of the Winter Meeting 9
Minutes of the Executive Committee 11
Minutes of the General Session 19
Memorials 20
Presidential Address 26
Program of the Section on Archeology 35
Papers on Archeology 36
Program of the Section on Botany 60
Papers on Botany 61
Program of the Section on Chemistry and Bacteriology 109
Papers on Chemistry and Bacteriology 110
Program of the Section on Geology and Geography 174
Papers on Geology and Geography 175
Program of the Section on Mathematics 205
Paper on Mathematics 206
Program of the Section on Physics 211
Papers on Physics 212
Program of the Section on Psychology 236
Papers on Psychology 237
Program of the Zoological Section 249
Papers on Zoology 251
Junior Academy of Science 335
List of Members 338
Index 341

OFFICERS FOR 1935

President, Will Scott, Indiana University.
Vice-President, W. E. Edington, DePauw University.
Secretary, Ray C. Friesner, Butler University.
Treasurer, W. P. Morgan, Indiana Central College.
Editor, Paul Weatherwax, Indiana University.
Press Secretary, T. R. Johnson, Purdue University.
Trustees Academy Foundation, F. B. Wade (Term expires 1935), Shortridge High School, Indianapolis; John S. Wright (Term expires 1936), Eli Lilly Company, Indianapolis.
Committee for Bonding Trustees, H. L. Bruner, Butler University; W. A. Cogshall, Indiana University. (This committee is appointed by the Executive Committee.)

Divisional Chairmen

Botany, A. R. Bechtel, Wabash College.
Chemistry and Bacteriology, M. G. Mellon, Purdue University.
Geology and Geography, C. A. Malott, Indiana University.
Physics and Mathematics, Mason E. Hufford, Indiana University.
Zoology, W. H. Johnson, Wabash College.

Executive Committee

(Officers and Past Presidents)

Andrews, F. M.
Arthur, J. C.
Bechtel, A. R.
Behrens, C. E.
Blanchard, W. M.
Blatchley, W. S.
Bruner, H. L.
Burrage, S.
Butler, A. W.
Cain, Stanley
Cogshall, W. A.
Coulter, Stanley
Cumings, E. R.
Davis, J. J.
Deam, C. C.
Enders, H. E.
Edington, W. E.
Foley, A. L.
Friesner, R. C.
Guernsey, E. Y.
Hessler, R.
Hufford, M. E.
Johnston, T. R.
Johnson, W. H.
Lyon, Jr., M. W.
Mahin, E. G.
Malott, C. A.
Martin, E. S.
Mellon, M. G.
Morgan, W. P.
Moenkhaus, W. J.
Mottier, D. M.
Naylor, J. P.
Nieuland, J. A.
Noyes, W. A.
Payne, F.
Ramsey, R. R.
Rettger, L. J.
Scott, Will
Wade, F. B.
Wallace, F. N.
Weatherwax, Paul
Wright, J. S.

STANDING COMMITTEES

(Appointed by the President)

Archeological Survey

E. Y. **Guernsey**, Bedford, Chairman
W. N. **Logan**, Indiana University
F. J. **Breeze**, Fort Wayne
C. A. **Malott**, Indiana University
E. R. **Smith**, DePauw University
Mrs. **Viva D. Martin**, Tech. H. S., Indianapolis

Auditing

E. S. **Martin**, Tech. H. S., Indianapolis, Chairman
N. E. **Pearson**, Butler University

Biological Survey

M. W. **Lyon, Jr.**, South Bend, Chairman
B. E. **Montgomery**, Purdue University
Winona Welch, DePauw University
C. M. **Palmer**, Butler University

Library

S. A. **Cain**, Indiana University, Chairman
J. E. **Switzer**, Indiana University
W. E. **Edington**, DePauw University

Membership

F. M. **Andrews**, Indiana University, Chairman
A. **Strickler**, Evansville College
M. S. **Markle**, Earlham College
Fred Donaghy, Indiana State Teachers College
Winona Welch, DePauw University
O. B. **Cristy**, Ball State Teachers College
F. B. **Wade**, Shortridge H. S., Indianapolis
E. R. **Martin**, Hanover College
F. J. **Wenninger**, University of Notre Dame
C. E. **Deppe**, Franklin College
C. L. **Porter**, Purdue University
Edward Kintner, Manchester College
F. R. **Elliott**, Valparaiso University

Program

A. R. **Bechtel**, Wabash College, Chairman
W. H. **Johnson**, Wabash College
C. A. **Malott**, Indiana University
M. E. **Hufford**, Indiana University
W. A. **Hiestand**, Purdue University
Theodore Just, University of Notre Dame
F. E. **Beghtel**, Evansville College.

Publication of Proceedings

J. J. **Davis**, Purdue University, Chairman
E. R. **Smith**, DePauw University
Frank B. Wade, Shortridge H. S., Indianapolis
M. E. **Hufford**, Indiana University
Paul Weatherwax, Indiana University, Editor

Relation of Academy to State

F. N. **Wallace**, State Department of Conservation, Chairman
W. N. **Logan**, Indiana University
John S. Wright, Indianapolis
Stanley Coulter, Indianapolis
L. M. **Pittenger**, Ball State Teachers College

Research

A. L. **Foley**, Indiana University, Chairman
John S. Wright, Indianapolis
E. G. **Mahin**, University of Notre Dame

W. E. EDINGTON, DePauw University
R. B. ABBOTT, Purdue University
C. C. DEAM, Bluffton

Academy Representative on Council of A.A.A.S.

H. E. ENDERS, Purdue University

Nominations

M. W. LYON, JR., South Bend, Chairman
C. C. DEAM, Bluffton
J. J. DAVIS, Purdue University

Junior Academy of Science

H. E. ENDERS, Purdue University
FRANK B. WADE, Shortridge H. S., Indianapolis
O. B. CHRISTY, Ball State Teachers College
L. J. RETTGER, Indiana State Teachers College
O. C. OSBORNE, South Bend
EDNA BANTA, North Madison
M. M. WILLIAMS, Bloomington

MINUTES OF SPECIAL COUNCIL MEETING

A special meeting of the Council of the Indiana Academy of Science was called by President Scott to meet at Greencastle, February 10, 1935. The following items were considered:

After considerable discussion the time and place of the spring meeting of the Academy was referred to the Program Committee with power to act.

Mr. John S. Wright presented a bill for $60.00 covering costs of diplomas presented to charter members of the Academy. At his request this bill was allowed to be paid by Mr. Wright and the amount of the bill transferred from the Academy general fund as a gift from Mr. Wright to the endowment fund.

Dr. Edington reported the deposit of film-slides of photographs of Academy members in the State Library. It was decided that these could be loaned upon approval of the President and the Secretary.

A committee was authorized to attempt to secure an "Academy Room" at the State Library. This committee consists of Dr. Edington, chairman, Dr. W. P. Morgan, Dr. T. R. Johnston, and R. C. Friesner.

It was voted to allow the Editor to use up to $600 from the general funds of the Academy toward publication of the Proceedings. The number of copies to be printed was left to the discretion of the Committee on Publication of Proceedings. It was tentatively decided, with final decision referred to the same committee, that authors should receive 25 reprints free and should order any additional copies desired direct from the publishers.

MINUTES OF THE SPRING MEETING

May 10-11, 1935

MOUNT VERNON, POSEY COUNTY.

President Scott called the meeting to order at 7:30 p. m. The minutes of the Council meeting held at Greencastle, February 10, were read and approved. Reports of progress were made by the chairmen of the committees appointed to develop Divisions of the Academy for archaeology, mathematics, and psychology. Thirty-three applicants were elected to membership in the Academy, and 66 members who are fellows in the American Association for the Advancement of Science were elected as fellows in the Academy. Reports were given by the Editor and by the Library, Program, and Junior Academy committees.

Following the business meeting an address of welcome was given by Judge Chambers, and discussion of the physiography, archaeology, plant life, and bird life of Posey County were given by M. M. Fidlar, Glenn A. Glack, R. C. Friesner, and S. E. Perkins III. Saturday was spent in field trips about Hovey's Lake, Half-moon Pond, and other places of scientific interest in the county.

WINTER MEETING

Program of the Fifty-first Annual Meeting of
THE INDIANA ACADEMY OF SCIENCE
Held at
WABASH COLLEGE
Crawfordsville, Indiana
November 7-9, 1935

Thursday, November 7, 1935

7:30 p. m. Meeting of Executive Committee, Yandes Library.

Friday, November 8, 1935

9:00 a. m. Registration, Memorial Chapel.

9:30 a. m. General Session, Memorial Chapel.

Address of Welcome—Louis B. Hopkins, President of Wabash College.

Business Session.

Necrology, Brief Comments by Stanley Coulter.

Clifford H. Alvey
George W. Finley
Carl A. Buhl
Oliver P. Jenkins
James M. Van Hook

Address, "A Review of a Century of Chemical Education in Indiana," by L. A. Test and F. J. Allen, Purdue University. (Published with papers on chemistry, pp. 166 to 173.)

Address, "Contrasts in Indiana in Temperature, Precipitation, and Length of Growing Season," by S. S. Visher, Indiana University. (Published with papers on geology and geography, pp. 183 to 204.)

11:00 a. m. Sectional Meetings.

For programs see:

Archeology, p. 36.
Botany, p. 61.
Chemistry and Bacteriology, p. 109.
Geology and Geography, p. 175.
Mathematics, p. 205.
Physics, p. 212.
Psychology, p. 236.
Zoology, p. 251.

12:00 m. Luncheon, Wabash College Gymnasium.

1:30 p. m. Technical Sessions for all sections.

4:00 p. m. Tea served to members of the Academy and their guests.

6:00 p. m. Annual Dinner, Masonic Temple.
Address of Retiring President, Will Scott, Indiana University, "The Aquatic Habitat." (Published in this volume, pp. 26 to 35.)

SATURDAY, NOVEMBER 9, 1935.

9:00 a. m. Junior Academy of Science.

9:00 a. m. Meeting of Entomologists, J. J. Davis presiding.
Meeting of Systematic Botanists, Theodor Just presiding.

10:00 a. m. Visit to Spring Ledge, home of Mr. Frank C. Evans.

MINUTES OF EXECUTIVE COMMITTEE

The Executive Committee held its fifty-first annual meeting in Yandes Library, Wabash College, November 7, 1935. The meeting was called to order by President Scott at 7:30 p. m. The following committee members, as well as a number of other Academy members, were present: A. R. Bechtel, W. M. Blanchard, W. A. Cogshall, J. J. Davis, C. C. Deam, H. E. Enders, W. E. Edington, A. L. Foley, R. C. Friesner, M. E. Hufford, M. W. Lyon, Jr., E. G. Mahin, C. A. Malott, W. P. Morgan, D. M. Mottier, Will Scott, F. B. Wade, Paul Weatherwax, John S. Wright. Reports of officers and committees followed:

Academy Foundation. Frank B. Wade, John S. Wright, and W. P. Morgan (ex officio), Trustees of the Academy Foundation presented the following report:

Balance from previous year	$ 192.69
Total receipts	313.02
Total	$ 505.71
Withdrawal to add to gift of $434 from friend of Academy in order to purchase bond	75.71
Balance in Indiana National Bank Savings Account	$ 430.00

Assets

U. S. Treasury Bonds, par value	$4,200.00
Consolidated Federal Farm Loan Bond, par value	500.00
Muncie Masonic Temple Preferred, par value	200.00
Standard Oil Indiana Common, par value	150.00
Savings Bank Balance	430.00
	$5,480.00

Archeological Survey. The following report from Chairman Guernsey was read:

The year 1935, as it refers to Indiana archeology, has been one of especial interest and accomplishment. Under the sponsorship of the Indiana Historical Society, as heretofore, field work has been continued in the region of the Ohio River, in two sectors, under the direction of Glenn A. Black and E. Y. Guernsey. The former has completed, with most gratifying results, the exploration of the notable Nowlin mound, Dearborn County. This mound, the largest so far scientifically examined in Indiana, appears of evident Adena affinity. Both as to the splendid preservation of the interments and the inclosing crib-like, log tombs, the Nowlin mound has proved unique. An extended report of Mr. Black's findings will be read before the Archeologic Section.

In the Ohio Falls sector, as reported last year, initial excavation of the Elrod village-site, at Clarksville, was then under way. In addition, a partial excavation of one of the mounds of the Prather group, near Charlestown, was successfully carried out. The culture affinity of the latter site lies quite probably with the so-called Fort Ancient, with striking similarities to the Gordon (Tennessee) and Madisonville (Ohio) sites. The Prather group, incidentally, is a component of a considerable series of similar sites extended over a rather wide area in Clark County. The material culture, as well, is related to that of the Newcomb site, Clarksville.

During 1935 two additional excavations of considerable area were completed at the Elrod site, in a quarter somewhat removed from the earlier excavation. Here, unexpectedly, the predominant culture was found identical with that of the "Indian Knoll" site, of Moore, on Green River, Kentucky. The form of burial, and the character of the accompanying material, differed, in fact, from that of the earlier dig. Extensive excavation of the Clark's Point village-site, some distance up the Ohio, revealed a like "Indian Knoll" affinity. A third site of the Clarksville series, lying between the two already mentioned, was excavated primarily for the recovery of pottery. This was found abundantly on the surface. Abundant quantities of related shreds were unearthed during the excavation of this site (Newcomb site), together with one perfect burial, numerous artifacts, and abundant animal material. No material suggestive of "Indiana Knoll" was here encountered.

From the three closely associated Clarksville sites, to date, one-hundred-eight burials have been removed for study. The quantity of artifacts, associated with or not included with burials, is so extensive that considerable time must be devoted to their study and placement. While it is probable that only two distinct culture-types appear here predominantly, apparently various tribes have occupied the locality as migratory camp-sites; hence there is an accumulated complex of surface material which is at times disconcerting.

Quite early in the season a survey of the extensive flint-quarry area of Harrison and Crawford counties was attempted by your chairman. It was discovered, however, that the region was too extensive, and two prolific in respect to individual quarries, work-shop sites, village-sites, rock-shelters, mounds, etc., to be consistently studied in a brief time. In short, the area in question occupies some fifteen square miles, each section of which deserves specific attention.

Because of a general awakened interest in Indiana archeology, and the realization that the opportunities for long-continued research are increasingly apparent, your chairman deems it most advisable not only to continue an encouragement of this group at the hands of the Academy, but to enlarge the present committees, include specialists in the field of geology, biology, and chemistry willing and competent to co-operate with field-workers in the matter of preparing future reports. It is obviously essential that an accurate and authentic geologic survey accompany such reports, and that much of the material recovered during excavation must be referred to specialists in various lines for determination or classification. It should be possible, certainly, to obtain such assistance from our own Academy group, and to avoid the present necessity of sending material out-state for identification.

Auditing Committee. Chairman Martin reported the Treasurer's accounts audited and found correct.

Biological Survey. Chairman Lyon reported that almost no new work had been done during the past year with the exception of that in two fields: (1) the report of the Mammals of the State with a complete bibliography is now in press and expected to be published as Vol. 17, No. 1 of the American Midland Naturalist, to appear early in 1936; (2) Deam has worked assiduously on the Flora of Indiana, and his report is rapidly approaching completion. The status of fossil biota, in charge of Dr. Malott, is the same as last year.

The various members of the committee and the collaborators, not seeing any immediate outlet for publication, are not any too enthusiastic about doing work which there is almost no prospect of having published.

The bibliographical work is of such a nature that additions have to be made to it from time to time as new titles appear. Probably the most complete bibliography on hand at the present time is that on Insects, in charge of Dr. Montgomery. The committee suggests that some arrangements be made with the State Library whereby the work that has been completed can be kept on file, and notation made as to persons who have completed bibliographies and still have them in their own possession, such as the Bryophytes, now held by its author, Dr. Winona Welch.

The committee recommends, as in previous years, the desirability of building a fireproof museum for the storage of scientific specimens which have been collected in Indiana, either in one of the state universities or in Indianapolis. A great deal of valuable material has been sent out of the state to other museums for lack of a suitable place for its preservation here. Some of our sister states, notably Illinois and Michigan, have excellent facilities for the care of scientific specimens.

Bonding Committee. Bonds for Treasurer and Academy Trustees have been renewed.

Editor. Editor Weatherwax presented the following report:

Volume 44 of the Proceedings was ready for distribution near the end of September. It consisted of 284 pages, about 225 of which were devoted to scientific and historical material. Of the 1,500 copies printed, 1,000 were bound in cloth and 500 in paper covers.

Separates were prepared for only those authors who ordered them. By order of the Council of the Academy, one-fourth on the cost of the first 100 reprints ordered by each author was defrayed by the Academy. This policy cost the Academy this year $56.34. Two hundred copies of Dr. Edington's historical article and 500 copies of the constitution, by-laws, and editorial policy were ordered for use of the Academy.

The net cost of printing the volume was $1,059.15; the cost per printed page for the 1,500 copies was $3.68. The total cost of the publication, including printing, engraving, reprints charged to the Academy, clerical help, and editor's expenses for postage and supplies, was $1,207.69. After deducting the $900 paid by the State, the total amount to be paid by the Academy is $307.69.

In the selection of material to be published, the recently adopted editorial policy provided a practical and apparently satisfactory guide. Manuscripts on which the editor did not wish to pass judgment were submitted to competent persons in the various fields, and the final selection was approved by the committee on publication.

Library. Chairman Cain presented the following report:

With the firm belief that the library of the Indiana Academy of Science is one of great value to Indiana scientists, and with an acute sense of its impaired usefulness due to the badly broken files, your committee has started some work which will improve the situation. Previous to the World War the State Library staff gave the necessary persistent attention required to keep periodical exchange files complete and up to date. During that generally disastrous period our exchanges fell into a bad state, following which the State Library staff found themselves too busy to care for our periodicals and see that we obtained the numbers due us on exchange. Also during the past decade and a half no Academy member has bestirred himself sufficiently to see that the Academy or the State Library take up this important but arduous task.

Our committee was made a special grant for securing the services of a trained librarian, who went through the files and the accession cards co-ordinating addresses in our mailing list with official addresses of exchange societies. He also noted what numbers and volumes were missing from our files and prepared a letter to each society asking that our files be completed if possible. Altogether 174 carefully prepared letters were written for missing numbers. With these letters were enclosed mimeographed lists of our publications with an indication of the volumes we still have available for exchange. In going over our files and accession cards it was found that we have many periodicals which are hopelessly incomplete, sometimes only a scattered number or two, and which it seems unwise to attempt to complete. Altogether 154 slips were made out to cover such cases. It is suggested that a list of these items be mimeographed with a view to sale or exchange. This list of items for disposal, carrying an approximate value, should be sent around together with a want list, with a view toward possible enchanges. All items, however, should be examined by a competent Academy member in each field of science previous to the preparation of the disposal list so that we do not inadvertently dispose of some especially valuable item. It is thought, however, that we hold many isolated numbers which are of little value to us but which would be highly prized by certain other libraries. At any rate the 154 records await the action of the 1935-36 committee. Another valuable piece of work accomplished through the grant was revision of our sending list so that it is possible to tell what we receive in exchange for our Proceedings. This work was carried on with the full cooperation of Miss Nellie Coats, Chief of the Catalogue Department, Indiana State Library, who is now continuing the work of revising our mailing list, as replies to our letters come in. The State Library provided request cards which are now sent as soon as it appears that we have missed a current number of any publication. It is hoped to extend exchanges to include valuable available publications now received by the Academy. It is thought that this is the next logical step.

Miss Coats has compiled a list entitled "Periodical Literature Currently Received by the Library of the Indiana Academy of Science, 1935".

The sum of $75 was made available for the continuation of the work of this committee.

Membership. Final report was deferred until the dinner meeting on Friday, at which time 57 applications for membership were reported and accepted.

Press Secretary. No report.

Program Committee. Chairman Bechtel presented the printed program containing 108 titles. The Executive Committee extended to him and his committee a vote of thanks for their efficient work.

Publication of Proceedings. Chairman Davis presented the following report:

The Committee on Publication of Proceedings has functioned in an advisory capacity to the Editor. It has acted upon a list of papers tentatively accepted for publication and those tentatively rejected before final action was taken by the Editor.

The Committee takes this opportunity to express its appreciation of the services of former Editor Stanley A. Cain, who from 1929 to 1934 was responsible for the publication of six volumes of the Proceedings, worthy of the high standing of this Academy.

Relation of Academy to State. Chairman Wallace was unavoidably absent but it was reported that the activity of the committee resulted in an appropriation of $1,000 by the State toward publication of Proceedings.

Research. Chairman Foley presented the following report:

For the first time your Research Committee is reporting a definite plan for increasing the research fund of the Academy—a plan which will be initiated within a week or two. The Committee has prepared a series of follow-up letters to the Indianapolis papers calling attention to the need for scholarships, fellowships, and endowments by universities and colleges in Indiana in general, and by the Indiana Academy of Science in particular, and further, to the fact that funds for such purposes are not merely an ever-increasing benefit to mankind but also constitute a memorial far more enduring than any marble shaft.

After reading the letters from each one of the five members of the Committee it is hoped that many members of the Academy will take enough interest in our research endowment fund to write letters to the home papers commending the memorial fund idea. If in your community there are now, or if there later come to be, those, who might be interested in memorials, we ask that you send to the Committee for mimeographed copies of all the letters of those who have endorsed the move and see that these letters get into the hands of prospective donors.

The members of the Academy are, or should be, just as much interested in the Academy research fund as are those who happen to have been appointed to the Research Committee membership. If all the Academy members will cooperate with the Committee as suggested above, we believe that in time our efforts will meet with success. Your passive interest is not sufficient. We must have your *active* support.

Treasurer. Dr. W. P. Morgan presented the following report to December 31st, 1935:

RECEIPTS

Balance on hand January 11, 1935 (transfer of accounts made on this date)	$ 978.03	
Dues and initiation fees collected	669.00	
Refund from A.A.A.S.	90.50	
Received from S. A. Cain, Editor	76.76	
Received from author's reprint accounts:		
Vol. No. 41	7.40	
Vol. No. 42	4.10	
Vol. No. 43	11.35	
Vol. No. 44	156.32	
From sale one copy Proceedings Vol. No. 44	3.24	
		$1,996.70

DISBURSEMENTS

1—Hotel charge for meeting place Ex. Comm.	$ 1.50		
2—Secretary	65.71		
3—Treasurer	14.55		
4—Program Committee	113.10		
5—Mailing Proceedings	89.08		
6—Bonds and Safety Box	20.50		
7—Stationery	19.68		
8—Committee on Anniversary Publicity	46.75		
9—To Academy Foundation	90.50		
9a—To Academy Foundation	59.95*		
10—To Editor	68.32		
11—Stafford Engraving Co.	137.41		
12—Wm. Burford Co.	262.53		
13—Leland R. Smith work on Academy Library	50.25		
		$1,039.83	
Balance in Bank		956.87	
			$1,996.70

*Item so marked was authorized by the Executive Committee. A gift of this amount was made in the form of the payment of an obligation of the Academy incurred during the Anniversary Meeting. Such gift was conditional upon the transfer of a similar amount to the Academy Foundation. The donor prefers to remain anonymous.

Signed W. P. Morgan, Treasurer,
Auditor Ersie G. Martin.

Junior Academy of Science. Chairman Enders presented the following report:

The Indiana Junior Academy of Science Clubs have maintained their activities unabated. Sixteen clubs were enrolled at the time of our last annual meeting. Two clubs were added during the year, and several others have been operating tentatively with a view to later affiliation. Your Chairman, at his own expense, visited every member club during March and April. He was afforded opportunity to discuss club activities, and in several instances to address related science clubs, or the whole high school.

Public presentations of the Junior Academy of Science project were made before the Chemistry teachers, at their meeting at Purdue University, May 17, and also before the Chemistry and Physics Teachers section of the State Teachers meeting at Indianapolis, October 17, at which time the Junior Academy Clubs of Shortridge and Technical High Schools of Indianapolis and the Bloomington Club set up very creditable exhibits to illustrate the work of the Junior Academy Clubs. Favorable impressions were made resulting in numerous inquiries upon the matter of the project. Preliminary literature was distributed to all who inquired. There are now eleven clubs in process of organization and one application ready to refer to the Membership Committee of the Academy. The Science Leaflets published at irregular intervals by Mr. Louis Astell, Sponsor of the Illinois Junior Academy of Science Clubs, were purchased and presented to our affiliated clubs with a view to the encouragement of their work.

Your committee recommends that the Indiana Academy of Science cooperate with the Illinois Junior Academy of Science in the publication of source materials for the Junior Academy clubs by the payment of twenty dollars to Mr. Louis Astell, Urbana, Illinois, for copies of the Science Leaflet to distribute to all of our affiliated clubs during the current year.

An appropriation of $20 for further promotion of this work was voted by the Academy.

A.A.A.S. Dean Enders reported a change in the per-member refund to the Academy after this year. Formerly the allowance was made in cash and added to the permanent endowment fund. The new plan calls for an equal or greater allowance but is to be paid directly in support of research projects carried on by members of the Academy.

Nominations. Chairman Lyon reported the following nominations for fellows:

T. M. BUSHNELL, Purdue University.
H. T. BRISCOE, Indiana University.
W. P. ALLYN, State Teachers College.
H. B. FRONING, University of Notre Dame.
WINONA WELCH, DePauw University.
DR. W. S. BLATCHLEY, Indianapolis, Honorary Fellow.

Archeology (Special Committee). Mr. Eli Lilly, chairman of this special committee appointed to organize a section of the Academy devoted to archeology, announced 20 new and a number of present members of the Academy interested in this section. The first program of this section was announced.

Mathematics (Special Committee). Dr. T. E. Mason, chairman, announced that a mathematics section within the Academy was meeting for the first time. Final disposition of the question of a permanent section was contemplated at the next meeting of the Mathematics Society.

Psychology (Special Committee). Dr. H. H. Remmers, chairman, reported the organization of a psychology section which was holding its first program.

New Business. Dr. Blanchard was appointed chairman of a committee to receive and make recommendations regarding invitations for the next annual meeting of the Academy. C. A. Malott and C. M. Palmer were appointed on the Resolutions Committee.

The Trustees of the Academy Foundation were instructed to bring in a recommendation at the next annual meeting regarding administration of the income from the endowment funds.

The sum of ten dollars was made available for furthering preservation of Academy historical material.

MINUTES OF THE GENERAL SESSION

Following the address of welcome by President Hopkins, of Wabash College, and the response by President Scott, the minutes of the Executive Committee were read and all recommendations approved.

At a brief business meeting following the annual dinner the following business was transacted: Dean Blanchard recommended that the next winter meetings of the Academy be held at Central Normal College, Danville, and the next spring meeting at Taylor University, Upland.

Dr. Malott offered the following resolution: "The Indiana Academy of Science assembled at Wabash College for its fifty-first annual meeting, desires to express its appreciation and thanks to the College and its officers and faculty for the friendly hospitality and the fine arrangements made for the meeting, and to those who have provided for our entertainment. The Academy is particularly appreciative of the services rendered by Dr. Bechtel and the other members of the program committee and their associates, who have contributed so liberally of their time and efforts to make this occasion so pleasant and worth while."

Chairman Lyon of the Nominating Committee offered the following nominations for officers for 1936:

President, **Ray C. Friesner**, Butler University.
Vice-President, **Edward Kintner**, Manchester College.
Secretary, **Louis A. Test**, Purdue University.
Treasurer, **W. P. Morgan**, Indiana Central College.
Editor, **Paul Weatherwax**, Indiana University.
Press Secretary, **T. R. Johnston**, Purdue University.
Trustee, **Frank B. Wade**, Shortridge High School.
Bonding Committee, **H. L. Bruner**, Butler University.
W. A. Cogshall, Indiana University.

These nominees were all unanimously elected.

Dr. Lyon announced the following Divisional Chairmen elected by the various sectional meetings:

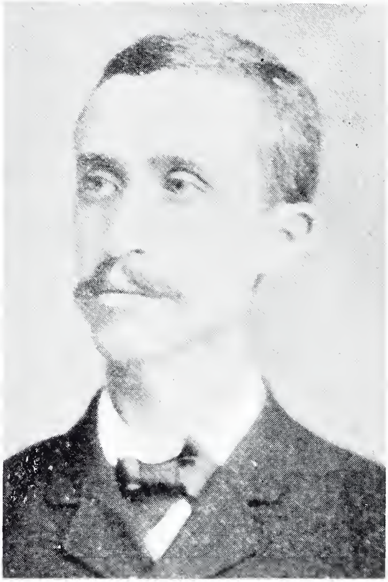
Archeology, **Glenn A. Black**, Indianapolis.
Botany, **Naomi Mullendore**, Franklin College.
Chemistry and Bacteriology, **J. M. Fulmer**, DePauw University.
Geology and Geography, **A. H. Meyer**, Valparaiso University.
Mathematics, **R. B. Stone**, Purdue University.
Physics, **G. W. Horton**, Wabash College.
Psychology, **E. S. Conklin**, Indiana University.
Zoology, **B. E. Montgomery**, Purdue University.

Ray C. Friesner, *Secretary.*

OLIVER PEEBLES JENKINS

BANTAM, OHIO.
November 3, 1850.

PALO ALTO, CALIFORNIA.
January 9, 1935.



OLIVER PEEBLES JENKINS

Perhaps few of us recall Dr. Jenkins—what a splendid teacher he was! An active mind—original, enthusiastic, and inspirational—and a fund of humor were outstanding characteristics. Who could not profit from his instruction? To those of us who were much with him he was a delightful companion and a lovable friend, in addition to his being a great naturalist.

He was born at Bantam, Ohio, November 3, 1850, and died at Stanford University January 9, 1935 in his eighty-fifth year. He was buried at Palo Alto, California. He married Elizabeth R. Hester, formerly of Brookville, Indiana, where the writer and his wife, Mary Reynolds, attended Brookville College with her. His widow and two sons survive.

He graduated from Moores Hill (now Evansville) College in 1869 and, after serving as teacher, high school principal, and superintendent in the public schools of Indiana, Wisconsin, and California, he returned, in 1876, to Moores Hill College as professor, where he remained for twelve years. That institution conferred upon him advanced and honorary degrees; he was also honored with a degree from Indiana University. He became a member of the faculty of the Indiana State Normal School, at Terre Haute in 1883, and left there to become Professor of Biology at DePauw University in 1886. He remained at DePauw until 1891, when he became a member of the faculty of Leland Stanford Jr. University at the time of its founding. He remained in this position until he retired as Professor Emeritus of Physiology in 1916.

He was for many years associated with David Starr Jordan on collectiong expeditions and with Barton W. Evermann in his work on fishes. His writings included works on the fishes of the United States and of Hawaii and on the nervous system of the invertebrates. He was also the author of the Indiana State series of textbooks on physiology.

Dr. Jenkins was one of the founders of the Indiana Academy of Science and its first treasurer. Faithful in all his duties and active in all the interests of the Academy, he was the life of every meeting that he attended. His humor will be remembered in connection with the seining at Brookville, in 1886, with the meeting at Indianapolis, when he resigned as Curator of Invertebrates, on an occasion when Maurice Thompson discussed two species of woodpeckers, and again at Waveland in discussing some specimens collected.

He was a fellow of the American Association for the Advancement of Science and a member of the Biological Society of Washington, the Washington Academy of Sciences, the California Academy of Sciences, the American Physiological Society, the American Society of Naturalists, the Cooper Ornithological Club, and the Western Society of Naturalists.

It is fitting that we should have also the words of one of his more recent colleagues, Dr. Elliott, of Stanford University, at the funeral in Stanford Memorial Church:

> The passing of another member of the pioneer Stanford faculty comes as a sharp reminder of the lapse of time and of the transitory nature of this human life of ours. We gasp a little at the closed door as we realize that the warm handclasp, the greetings, and the friendly talk are over.
>
> But, when life has been long—far beyond the scriptural threescore years and ten,—and the work is done, and only the days of waiting and suffering are here, we cannot ask that they be lengthened.
>
> This is not the time, nor do we wish here and now, to recall the doings and the strivings which make up the long record of this life. But we may turn back and, looking down the corridors of memory, try to realize what it has all meant to us, who were his friends and neighbors, and to the wider circle which he touched.
>
> Dr. Jenkins was one of the three department heads selected by Dr. Jordan and placed over the biological sciences at the beginning of the University. They were all men in his own field, whom he knew thoroughly, with whom he had worked, and each his first choice for the position. He had made no mistakes.
>
> Dr. Jenkins was a great teacher, because he exalted his department and because he was able to carry over to his students his patience, his love of exactness, and his deep conviction that, in its time and place, no other work could be more worth while.
>
> He was staunchest of all, perhaps, in his devotion to Dr. Jordan's fundamental ideas in establishing the University. He never wavered or compromised in his advocacy of freedom of action and freedom of choice in school and college. He was reformer as well as teacher. Indefatigable in attendance at teachers' institutes and other educational gatherings, and at the Schoolmasters' Club, be was always proposing or defending reforms in educational ways and methods. Unassuming, companionable, friendly, his pungent strictures could be enjoyed whether or not one might go so far.
>
> Dr. Jenkins was a notable member of the Stanford Academic Council, not that he said very much in Council meetings, but, when he did speak, his words were weighty, and his dry, salty wit punctured right through to the bottom of any confused structure that might have been raised.
>
> Dr. Jenkins was a good colleague and a good companion. The early pioneers were loyal. They took good fortune and evil fortune in the same spirit. They did not shirk. They made bricks whether there was any straw or not. There was no greater among them than Dr. Jenkins—in the quality of devotion to Stanford ideals, of willing co-operation, in honor preferring others, in the respect and affection of students and teachers. In parting, I think we have toward Professor Jenkins a more tender feeling, perhaps, than toward some of the giants in his company. We rejoice while we sorrow, in the conviction that he now is, and will be, so long as memories last, honored among his peers in the Stanford Pantheon.

AMOS W. BUTLER.

JAMES M. VAN HOOK

WASHINGTON COUNTY, INDIANA.
December 19, 1870.

PENTWATER, MICHIGAN.
June 20, 1935.

JAMES M. VAN HOOK

Professor James M. Van Hook was born in Washington County, Indiana, on December 19, 1870, and died at Pentwater, Michigan, June 20, 1935. He married the former Elizabeth Karsell in 1901. Survivors include the widow, a son, James M. Van Hook, Jr., Grand Rapids, Michigan, a daughter, Mrs. Woodrow Adams, Bloomington, a brother, and a sister.

Professor Van Hook attended the public schools and graduated from the Borden Institute, of Borden, Indiana, in 1894. He attended Indiana University, receiving the A. B. degree in 1899 and the A. M. degree in 1900. He then attended Cornell University as a graduate student and assistant in botany for a period of one year. From 1902 to 1904 he was assistant in plant pathology in the extension department, Cornell University. During his graduate work at Cornell he studied under Professor G. F. Atkinson. From 1904 until 1907 he was assistant botanist, Ohio Agricultural Experiment Station, with principal work in plant pathology, and was author of a number of station bulletins dealing with plant diseases.

During his graduate work at Cornell and later at the Ohio Agricultural Experiment Station, much of his research work was devoted to the diseases of ginseng. His findings were an important contribution to our knowledge of the diseases of ginseng and their control, and his work still stands as significant in its field.

In 1907 Professor Van Hook returned to Indiana University as Assistant Professor of Botany. He was promoted through the various ranks, receiving the title of Professor in 1925. At the time of his death he had thus completed almost three decades of service in Indiana University.

During this period of service there were many students to teach, and a large part of this load fell to him. His teaching was characterized by an enthusiasm for his work and an ability to impart this enthusiasm to the interested student. He was acquainted with related fields as well as his specific subject and was able to present the facts and relationships clearly and concisely. He unselfishly shared his time and energy, in and out of the classroom and laboratory, in personal sympathy and instruction. This seemed to him more important than fine-drawn definitions and excessive theory in teaching. I am not aware that Professor Van Hook ever took a formal course in education, but I am certain he possessed the qualities of a highly successful teacher. His broad experiences and thorough training in mycology and pathology were brought to play in his teaching, and that his ability was recognized and appreciated was evidenced in the number of graduate students working under him for advanced degrees.

During his twenty-eight years of teaching at Indiana University his research was for the most part in mycology with an occasional problem in plant pathology. His special study was with the Fungi Imperfecti. Unfortunately much of his work on this group remains unpublished.

In his work Professor Van Hook was opposed to the making of new species but believed, where possible, a greater service could be rendered botanical science by a careful study of material collected in quantity and in various stages of development, and appending corrections and additions to already given meager discriptions. His extreme conservatism in naming new species is evidenced in the amount of unpublished work on new species of imperfect fungi. His work on parasitic fungi was greatly enhanced by his familiarity with the taxonomy of the native host plants; he also was a specialist on ornamental plants.

By natural inclination Professor Van Hook was of a quiet and retiring disposition. I believe few realize the extent and variety and thoroughness of his attainments. As a foundation he was well schooled in the classical languages and literatures and in music. He was a skilled craftsman. He brought these accomplishments to his service as scientist; and through all he was a gentleman and a man of character.

His friendships were deep and lasting. Those who knew him recognized and admired his integrity, sincerity, kindness, and loyalty and were impressed with his knowledge, skill, and ability in the field of botanical science which he loved.

Professor Van Hook's interest in every thing life presents, made him a valuable member of his home and university community,—made him an enthusiastic cooperator in all efforts to make life more beautiful in every way and more enduringly satisfying.

Professor Van Hook was a fellow of the American Association for the Advancement of Science and of the Indiana Academy of Science, a charter member of the American Phytopathological Society and of the Mycological Society of America, and a member of the Crop Protection Institute, the Botanical Society of America, Phi Beta Kappa, and Sigma Xi.

Bibliography

1900. Notes on the division of the cell and nucleus in liverworts. Bot. Gaz. **30**:394-399.

1902. Pink rot, an attendant of apple scab. (Craig and Van Hook.) Cornell Expt. Sta. Bull. **207**:157-172.

1904. Diseases of ginseng. Cornell Expt. Sta. Bull. **219**:163-186.

1906. Ascoctya Pisi, a disease of seed peas. Ohio Nat. **6**:507-512.

1904. Brown rot, its effect on fruit, twigs, leaves and blossoms. Ann. Rept. Ohio State Hort. Soc. **38**:141-147.

1906. A cause of freak peas. Torreya **6**:67-69.

1906. Blighting of garden and field peas. Ohio Agr. Expt. Sta. Bull. **173**:231-250.

1906. A disease of ginseng due to Phytophthora. Special Crops **5**:94.

1907. Dying of bearing grape vines. (Shelby and Van Hook.) Ohio Agr. Expt. Sta. Circ. **64**.

1907. Celery root rot. Ohio Agr. Expt. Sta. Circ. **72**.

1911. Indiana Fungi. I. Proc. Indiana Acad. Sci. **20**:205-212.

1912. Indiana Fungi. II. Proc. Indiana Acad. Sci. **21**:347-354.

1913. Indiana Fungi. III. Proc. Indiana Acad. Sci. **22**:99-101.

1916. Indiana Fungi. IV. Proc. Indiana Acad. Sci. **25**:141-148.

1921. The perithecium of Ciccinobolis. Proc. Indiana Acad. Sci. **30**:215-216.

1921. A tricotyledonous bean. Proc. Indiana Acad. Sci. **30**:217.

1921. Indiana Fungi. V. Proc. Indiana Acad. Sci. **30**:209-214.

1922. Indiana Fungi. VI. Proc. Indiana Acad. Sci. **31**:143-148.

1924. Indiana Fungi. VII. Proc. Indiana Acad. Sci. **33**:233-238.

1925. Indiana Fungi. VIII. Proc. Indiana Acad. Sci. **34**:317-320.

1926. Indiana Fungi. IX. Proc. Indiana Acad. Sci. **35**:333-336.

1928. Indiana Fungi. X. Proc. Indiana Acad. Sci. **37**:365-371.

1929. Indiana Fungi. XI. Proc. Indiana Acad. Sci. **38**:127-131.

1929. Some new species of Fungi. Proc. Indiana Acad. Sci. **38**: 131-132.

1930. Indiana Fungi. XII. Proc. Indiana Acad. Sci. **39**:75-83.

1935. Anthracnose of Betula nigra. (Van Hook and Busteed.) Proc. Indiana Acad. Sci. **44**:81.

1935. Indiana Fungi. XIII. Proc. Indiana Acad. Sci. **44**:55-64.

ROBERT C. BUSTEED.

CARL A. BUHL

CHICAGO, ILLINOIS.
September 3, 1913.

CHICAGO, ILLINOIS.
January 15, 1935.

CARL A. BUHL

Carl Buhl was born in Chicago and remained a resident of that city during the whole of his short but worth-while life.

He attended the grade schools and was graduated, with honors, from the Lake View High School in 1931. While there he stood high in all his courses but showed marked interest and ability in botany.

On entering the University of Chicago he continued his good record, receiving honorable mention for general excellence in scholarship at the end of two years, and, at the time of his death, he was within a few months of receiving the degree, Bachelor of Science, with honors in botany. As a fitting tribute to his worth, the degree was conferred posthumously.

Although only twenty-one years of age at the time of his death, he had already published two papers on botany and had another in press. He had also made considerable progress in a taxonomic study of the genus Desmodium.

Bibliography

1934. Supplement to an annotated flora of the Chicago area by H. S. Pepoon. Bull. Chicago Acad. Sci. 5:5-12.

1935. Notes on the flora of the Indiana dunes. Amer. Midl. Nat. **16**:248-253.

1935. Nomenclature of some species of Cornus. Rhodora **37**:222-223.

PRESIDENTIAL ADDRESS

THE AQUATIC HABITAT

Will Scott, Indiana University

Two fundamental problems of biology are: (1) the nature of living matter and (2) the conditions under which organisms can and do exist. So far as we know, living matter is confined to a thin shell about the earth. This stratum is probably never more than twelve miles thick. Mt. Everest is 29,002 feet high. Little if any life exists on its frigid summit. A few spores may be blown across it, but at such a point the layer of living matter must be very tenuous. The Swire deep of the Pacific is 32,089 feet, and little life exists above the surface of the open ocean, so that the limit in this situation is a little over six miles. On the land surface life extends but a few feet into the soil and to an unknown height above it. Birds are usually confined to the first half mile although some have been observed occasionally at the height of approximately two miles. Spores have been collected by aeroplanes flying at an elevation of 18,000 feet.

In this thin layer, organisms exist in one or the other of two habitats, air or water. It is incorrect to speak of land and water organisms, because the land or lithosphere underlies both the air and water oceans, that is, the atmosphere and the hydrosphere.

The differences between these habitats are rather obvious, but the import of their differences is not always seen, possibly because they are so obvious. Water has a specific gravity near that of protoplasm. As a consequence, organisms exist at any level in the water—not only one-celled organisms but relatively large ones. More than twenty species of fish live in the ocean at depths exceeding a mile. Many groups of organisms fly (or swim) in the water. In the air ocean only four groups of animals have been able to leave the bottom for any length of time. These are the Pterodactyls of the Mesozoic and the insects, birds, and bats of modern times.

Air varies in humidity from saturation to the extreme aridity of some of our deserts. No animal was able to invade this environment until it had developed a device which would enable it to keep its respiratory surface moist in air of varying humidity. Only four of the five classes of arthropods and three of the seven classes of vertebrates have been able to do this. With rare exceptions, members of the other eighteen or twenty phyla remain aquatic.

In air there is always a sufficient amount of oxygen for life at any level of metabolism. Moreover, air is extremely mobile, never stagnant. On the other hand, water at 20°C, saturated with oxygen, contains only about four per cent as much oxygen as an equal volume of air at the same temperature. Water is always less mobile than air, and in ponds and lakes it is often stagnant for long periods, so that in its lower levels the amount of oxygen is reduced or may entirely disappear. It is no accident that the only warm blooded animals which we have breathe air. There never has been and never will be an animal of constant temperature with aquatic respiration.

Carbon dioxide constitutes only .03 of one per cent of the air. However, under a given pressure it is more easily absorbed by water than is oxygen; although small amounts of carbon dioxide can be absorbed by water from the air because of its slight pressure, many natural waters have a large reserve of this gas available for photosynthesis in the second radical of the bicarbonate of calcium and to a lesser extent of magnesium. In most of the natural waters of our state photosynthesis is not limited by the lack of carbon dioxide. The amount of carbon dioxide and oxygen in natural waters is influenced by three processes, photosynthesis, respiration, and decay. The first reduces the amount of carbon dioxide and increases the amount of oxygen. In respiration and decay the process is reversed. In lakes photosynthesis takes place in the well-lighted upper levels, respiration occurs at all levels, while organisms disintegrate chiefly at or near the bottom where the amount of oxygen is limited and often exhausted. This distribution of these three processes is the basic cause of the filling up of our lakes with organic matter. Because of the availability of carbon dioxide photosynthesis is not limited, while decay is limited by the amount of oxygen near the bottom of the lake, which is in turn limited by the summer and winter stagnation of the lake. So much for the comparison of these two habitats.

Now a word about some of the characteristics of water. The physical chemists are agreed that it is not simply H_2O. Declaux ('12) has pointed out that because of its atomic weight such a compound should boil at about — 100° C. It may be H_4O_2 or H_6O_3 or a mixture of all three of these compounds to which Sutherland ('00) has given the names of monohydrol, dihydrol, and trihydrol. Water dissolves most substances. Whatever our notion of the nature of a solution, the fact remains that any substance dissolved in water can be recovered in its original amount and form.

Another striking and biologically important characteristic of water is its high surface tension of seventy-five dynes. In this it exceeds all other substances save mercury. It is this property that has made possible the invasion of water by many adult insects.

In the further discussion of the aquatic habitat I shall confine my remarks to fresh water. The fresh waters of the earth are divided by the presence or absence of gravity currents into ponded waters and flowing waters.

Lakes. A lake is probably the most self-contained autonomous habitat on earth. About forty years ago Eigenmann ('95) referred to this characteristic of a lake by calling it a unit of environment. About the same time Forbes ('87) called a lake a microcosm. Salts and, in swampy areas, organic compounds in solution are carried into lakes by its affluents. Smaller amounts of these materials are removed by its effluent. There is an exchange of gases with the air. With these exceptions a lake is a closed metabolic system.

In a field, a pile of leaves decays. Carbon, in the form of carbon dioxide, and nitrogen, probably in the form of ammonia, become a part of the great mobile air ocean and are widely distributed. The salts are either washed away by water or become a part of the soil. You pass this slowly decaying debris with no offense from odors because its products are so rapidly and widely distributed.

In a lake a similar mass of organic material would produce carbon dioxide, which would go into solution, as would the ammonia. This ammonia would be oxidized into nitrites into nitrates, to be used again by plants and then by the animals. Some of the mass would go into solution as colloids. Most of the contained salts would go into solution. If this occurred in a stagnant region of a lake, the available oxygen might become exhausted with the disintegration continuing under anerobic condition. As I have already pointed out, there is often a residue which becomes a part of the permanent lake deposit.

The degree of autonomy varies widely. At one end of the series might be placed the so-called Lake Pepin, which is caused by the partial damming the Mississippi River by the delta of the Chippewa River. It receives the drainage of the whole upper Mississippi Valley, and its entire volume is discharged in a relatively short time. The opposite extreme is found in Crater Lake of Oregon the area of whose drainage basin but slightly exceeds the surface of the lake. Except for gaseous interchange with the air it is almost wholly autonomous.

Almost all physical and chemical peculiarities of lakes are the result of the relation of the specific gravity of water to temperature. The fact that the point of maximum density is approximately 4°C. (3.98°) accounts for the formation of the ice at the surface of the lake. In the process of warming, the heat, of course, is received at the surface. Until a temperature of 4° is reached, this surface water is continually becoming heavier, and the lake would finally mix by convection, although actually the wind assists in the mixing process.

After the point of maximum density is passed, the heat can be carried to the lower levels by wind alone. This becomes increasingly difficult as the temperature increases above this point. The difference in weight per cubic centimeter of two layers of water whose temperatures are 4°C. and 5°C., respectively, is .000008 gm., while the difference between two layers of 24° and 25° is .000252 gm. It will, therefore, take thirty-one times as much energy to mix the two layers having the higher temperature as it would the two layers having the lower temperatures.

By late spring or early summer this thermal resistance to mixture becomes so great that the highest winds are not sufficient to mix the water of a lake to more than a limited depth. This upper layer that can be disturbed by the wind during the summer is five meters thick in Winona Lake. Its thickness varies with the size of the lake and the exposure of its surface to the wind.

The result of this peculiarity of water is that, during the late spring, summer, and early autumn, lakes in temperate latitudes are thermally stratified. There is a warm upper layer, an intermediate layer in which the temperature declines rapidly from top to bottom, and a lower layer which is relatively cold. These three layers are called respectively the *epilimnion*, the *thermocline* (mesolimnion) and the *hypolimnion*.

The water of the epilimnion is periodically exposed to the air and receives the maximum amount of illumination. The thermocline is not exposed to the air but usually receives some light. The hypolimnion is sealed from the air and receives little or no light.

The oxygen is gradually reduced in the hypolimnion. In about one-third of the lakes examined in Indiana the oxygen is entirely exhausted from the lower levels by mid-summer. Some chironomids, annelids and protozoa are able to survive from four to five months under these conditions. Just how they are able to do this has not been satisfactorily explained. When this condition becomes too severe, the bottom macrofauna disappears. Heriff Lake has an area of about 4 acres (1.6 hectares) and a depth of 4 m. Its original area was about 200 acres. It is surrounded by a marsh covered with maple trees about 50 feet in height. As a result of its small size and the protection it receives from the wind, its stratification is extreme. On July 18, 1934, it had dissolved oxygen at .5 meters but none at one meter. On the same day, 1935, it was examined after a severe storm and a trace of oxygen was detected at 1 meter. Although the bottom was dredged extensively, no macroscopic organism was detected except Corethra, which is known to migrate vertically. May I add a few incidental remarks concerning this unique and interesting lake? The Secchi's disc disappeared at 5.6 cm. The water was deeply stained. In this thin epilimnion was a dense plankton population which included Diaptomus, *Daphnia longispina*, and Ceratium. Several fishes were seen. One bass, twelve inches long, was taken. Scale examinations showed that it had grown rapidly for the first two years and thereafter very slowly.

In the epilimnion there is usually plenty of oxygen. Theoretically, there should be a diurnal oxygen pulse, but it is very difficult to demonstrate due to the mixing of the water by wind. After many trials, I succeeded in demonstrating it in Winona Lake (Scott '23). The pulse is always higher in the weedy littoral than in the pelagic region. The maximum was reached at 5:30 p. m.

Supersaturations of oxygen may occur in both the epilimnion and the thermocline, but their development and duration are quite different. In the epilimnion the supersaturation may develop whenever there is a period of calm weather and there are sufficient algae. With the first wind the supersaturation is obliterated.

In some lakes the position of the thermocline and the transparency of the water are such that considerable light reaches the thermocline. Under these conditions an algal flora may develop which produces a little more oxygen each day than is consumed in respiration and decay. This slight excess of oxygen, being under some hydrostatic pressure, does not escape. It is not influenced by wind. The effect, however, is cumulative, and a relatively high supersaturation may occur. This supersaturation may persist for some weeks. It remains for some time after the algae which produced it have disappeared.

In Lake Gage on July 6, 1929, at 8 meters the oxygen amounted to 158% saturation. This was associated with a rather dense flora of Lyngbya. Four weeks later the amount of Lyngbya had declined, but the oxygen saturation had decreased only slightly to 153%. A similar observation has been reported by Birge and Juday ('11) for Garvin and Knights Lake.

The thermoclinal supersaturation differs from that of the epilimnion in that it is not subject to the influence of wind. The oxygen accumulates over a longer period. The supersaturation is usually higher and lasts much longer. The complete history of a thermoclinal supersaturation has not been determined. The saturation in the epilimnion develops during relatively calm weather and is terminated by the first windy day. This condition is most likely to develop in small lakes which are protected from wind.

What I have called the thermoclinal oxygen notch is an interesting phenomenon. It developes in mid-summer in lakes of considerable depth and with a rather rich plankton. In these the amount of oxygen declines rapidly in the supper part of the thermocline and then increases in the lower part of the thermocline or the upper part of the hypolimnion. This is followed by the usual slow decrease to the bottom of the lake. In some lakes the oxygen entirely disappears at the level of this notch. In such a lake there usually is a region near the bottom without oxygen, then a level with oxygen, above this, the oxygenless level of the thermocline, and finally, the well-oxygenated epilimnion

Snow Lake and the third basin of James Lake of Steuben County develop this condition and also have cisco. The cisco prefer cool water and, of course, must have oxygen. In early summer they live in the hypolimnion; as the oxygen begins to disappear from the lower levels of the lake, they are forced upward. In early August they are trapped between two oxygenless levels. Soon after the first of September their oxygen supply becomes so reduced that they are partially asphyxiated and come struggling to the surface. Here they soon recover and descend as far as the oxygen of the upper levels permit.

The most characteristic element of the fauna and flora of a lake is the plankton. The word *plankton* was first used by Heusen to include all small organisms floating in the sea, "Alles was im wasser treibt."

In lake work the term *plankton* has come to mean a very definite association of organisms found in the pelagic or open part of the lake. The organisms are small and have a specific gravity near or quite identical with the particular water in which they occur. Some of them migrate vertically, but their horizontal movements are for the most part passive.

A rather large element of the plankton is cosmopolitan in its distribution. *Daphnia longispina*, *Bosmina longorostrus*, *Cyclops leuckartii*, *C. serrulatus*, *C. phaleratus*, and *Keratella cochlearis*, for example, may be expected in any lake in the world. The wide distribution of this group of organisms, this sameness of the plankton of lakes, is associated with the similarity of the pelagic region of different lakes. There is less difference between the pelagic region of a lake in Indiana and one in Holstein than may be found in the littoral of almost any lake. Not only that, but the pelagic area changes very slowly. This cosmopolitanism is the result of rapid distribution, or age, or possibly both. If the distribution is very rapid, the length of time required for cosmopolitan range need not be so great.

These two factors are difficult to separate. Viable eggs of these crustacea have been taken from the stomachs of fishes. It has been suggested that if the fishes were eaten by birds, the eggs would probably survive. This has not been demonstrated. Some of these forms have been found attached to birds' feet. I have found a colonial protozoan attached to aquatic beetles. These protozoa were active after remaining in the air all night. Migula ('88) enumerated 23 species of algae from aquatic beetles.

We do not have adequate data on the influence of birds on the distribution of aquatic invertebrates. Experiments are needed to determine what eggs or spores of these forms pass through the alimentary tracts of various water birds. If such experiments give affirmative results, it will help to answer a long discussed question.

Some genera are cosmopolitan while their species are strikingly local. In a closely related group the species may be widely distributed. The American species of the copepod genus Cyclops are almost if not quite identical with those of Europe, while in the genus Diaptomus there are more than thirty species peculiar to America and none identical with those of Europe. Practically all of the lakes of the northern hemisphere came into existence with the melting of the ice of the last Pleistocene glaciation. Lake Tanganyika of Africa is much older, and a comparison of their faunas is of interest.

Tanganyika is the most southern of the series of deep African lakes lying in the "great rift" whose formation Suess places in the Miocene. The finding of a jelly fish in this lake first suggested a marine origin for the fauna. Moore ('03), who led the first two expeditions of the Zoological Society for the exploration of this lake, concluded from the study of the fauna, and especially the molluscs, that the fauna was closely related to that of the marine Mesozoic. The geology of the region does not support this view. The subsequent work of Cunnington ('20) and others indicates that here, in a lake fauna that has been pretty well isolated since the Miocene, many of the forms have become unique. The long spined gastropods, for instance, closely resemble marine shells. Not only is it a case of convergence, but they suggest the bizarre characters of senescence familiar to every paleontologist. In the plankton of this lake are the following cosmopolitan forms: *Cyclops leuckartii*, *C. albidus*, *C. serrulatus*, *C. phaleratus*, *Branchionus angularis*, and *Keratella cochlearis*. The question of the relation of the cosmopolitan to the endemic species is complicated by the systematist. Of the twenty species of copepods listed by G. O. Sars ('09), fourteen were described as new. Two of these were described from single individuals and four of the remainder from single collections.

This question is further complicated by seasonal variation. In temperate latitudes where this has been studied, the Cladoceras, for instance, are much more alike in winter than in summer. Wesenberg-Lund ('08) has said that in Denmark during the summer, he can usually tell from what lake a daphnid has come, while in winter they are nearly if not quite identical.

This seasonal variation of the plankton has been attributed to changes in viscosity, specific gravity, and locomotion in relation to food.

Some light on the question of cosmopolitanism of plankton may be obtained by a study of the development of the plankton in a new artificial lake. When a pond or lake is first formed, it is usually some years before a typical lake plankton develops. Either the organisms are unable to reach the lake, or something must happen in the lake to make it suitable for the plankton. In one of our state forests there are three lakes, recently constructed. Last summer I planted in one of these lakes a complete complement of lake plankton. A recent examination showed that the plankton is surviving in this lake, while in the control lake the only plankton forms are blue-green algae. The question of the cosmopolitanism of lake plankton, its age, and its methods of distribution, remains intriguing, complicated, unanswered.

Streams. Streams differ from lakes in the presence of current and their greater dependence on land. Green plants occur in streams in one of three situations. In clear well-aerated streams, with stony or gravelly bottoms, Cladophora and similar attached algae are found. In streams whose rate of discharge is relatively constant, aquatic phanerogams develop if the current is not too rapid. Such streams are often the outlets of lakes. In our state the upper Tippecanoe, the Pigeon and the Fawn rivers are good examples. Last summer we weighed the plants from fifty-two quadrats in the upper Tippecanoe. The average weight was 2.9 Kilos. per square meter, which is a trifle less than 13 tons per acre wet weight. The dry weight was approximately 10% of the wet weight.

Streams rich in organic matter, domestic sewage, for example, with proper temperature, produce a dense growth of blue-green algae.

In other situations, streams are wholly dependent on land for their basic organic material. In small streams, where the relation of shore line to area is high, a considerable number of insects and bits of plants reach the stream more or less by accident. In larger streams whose levels fluctuate, much organic material is washed into the stream bed from its flood plain.

There has been a notion that temperature is the principal factor influencing the amount of oxygen in streams. Butcher, Pentlow, and Woodley ('30) have called attention to the influence of plants, pollution and turbidity in their work on three small rivers of England—the Itchen, Lark, and Tern. These influences are most marked during the summer. The Itchen is "clear, rapid and unpolluted." On July 27 its oxygen content was 121% saturated at 2:00 p. m. and 69% at midnight. The Lark, which is slow-flowing, contains plants in abundance, and is polluted by a beet sugar factory, had the following per cents of oxygen saturation on June 27; at 6:00 p. m., 165%; at 6:00 a. m., only 36%. The Tern, which is "moderately rapid", often turbid, and never clear, varied from 96% at 4:00 p. m. to 87% at 11:00 p. m.

In winter they were much more alike, and the diurnal variation was less. On December 14 the Itchen varied from 88% to 84%. On February 16 the Lark varied from 77% to 66%. The variation in the Tern on January 29 was from 87% to 79%. In each instance I have given the maximum and the minimum.

Denham, working on White River, found that clouds for an hour during the day made a notch in the diurnal curve.

At some distance below the point where sewage is discharged into a river there occurs what is known as the oxygen sag. That is, some oxygen is in solution at the point where the sewage enters but the decay of the organic material soon depletes this supply. However, algae soon begin to develop in this rich solution and suspension of organic material and the influence of photosynthesis is soon apparent. Denham traced this influence from the Indianapolis plant to a point 169 miles down the river. He was able in eight days to complete five 24-hour series at points approximately 6, 26, 61, 113, and 169 miles from the point of discharge. The diurnal variations in oxygen expressed in per cent of saturation were for these five stations, respectively, 4-0, 118-18, 295-94, 151-64, and 132-72. So far as these observations go, the maximum diurnal variation occurred at 61 miles, which is just below the town of Gosport.

The plankton of streams is a puzzling subject. Current seems to be inimical to its development and maintainance. It is well-known that in an effluent of a lake the plankton soon disappears. Whenever a river is rich in organic matter, especially in that which produces ammonia, blue-green algae are numerous. Rotifers are usually associated with these. With a slight rise in level, and consequent increase in velocity, the number of diatoms in the plankton increases.

Kofoid ('08) in his work on the Illinois River decided that its plankton was derived from the shallow lakes of its flood plain. I found a similar thing in studying the plankton of a cave stream. Here the source was a particular type of solution pond. These ponds are formed by the occlusion of a sink hole. In some of these a second opening at a higher level was formed. In rainy weather the pond overflowed into the cave below through this secondary opening.

Allen ('20) studied the plankton of the San Juan River from three stations. Two of these stations were located on lateral canals. The third station, located on the main stream, occasionally had Cladocera and similar typical lake plankton forms. Tulare Lake is sometimes flooded into the San Juan. In the upper course of King's River, the principal tributary of the San Juan, there are at least seven mountain lakes. The relation of these lakes to the river plankton was not determined.

Eddy ('34) has held in a recent paper that the amount of plankton in a stream is proportional to the age of the water. He based this conclusion on a study of the plankton in a reservoir in the Sangamon River. The river was not studied below the dam, which would have helped determine whether it was the age of the water or the ponding which was associated with plankton development.

Behning ('29) finds in the lower Volga, near the delta, a very complex plankton similar in its components to lake plankton. Even delicate forms like Leptodora are present.

The Volga has a low gradient and consequently slow current. If there are not tributary ponded waters, it is difficult to see how a floating society like the plankton can be maintained. The Volga has very high summer floods, on the recession of which, Benring points out, many eggs and spores of these forms are left on the banks and flood plain. It is thinkable that waterfowl, migrating north, might carry these eggs upstream and thus complete the cycle.

It is obvious that this phenomenon should be studied over a whole river system through all the seasons.

I am forced to omit many things. I should like to have told you something of the studies of Birge and Juday ('29) in the penetration of solar energy, of various wave-lengths in different types of water, of the work of Woltereck ('28) in the modification of daphnids by transplantation, of the refined experimental work now being done at Aneboda (Nauman, '28), the factors that are involved in the vertical immigration of plankton, the factors influencing the distribution of bottom fauna, and many other interesting and important phases of fresh water and its organisms. However, I trust I have given you a little glimpse at what Sir John Murray once called the most ancient of organic habitats.

Literature Cited

1. Allen, W. E., 1920. A quantitative study of the plankton of the San Joaquin River and its tributaries near Stockton, California, in 1913. Univ. Calif. Publ. Zool. **22**:1-292.

2. Behning, A., 1929. Ueber das Plankton der Wolga. Verh. Int. Ver. Theor. u. Angew. Limn. **4**:192-212.

3. Birge, E. and Juday, C., 1911. The inland lakes of Wisconsin. The dissolved gases of the water and their biological significance. Bull. Wisc. Geol. and Nat. Hist. Surv. 22. Sci. Ser. **7**:1-259.

4. Birge, E. and Juday, C., 1929. Transmission of solar radiation by the water of inland lakes. Bull. Wisc. Geol. and Nat. Hist. Surv. **24**:509-580.

5. Butcher, R. W., Pentlow, F. T. K., and Woodley, J. W. A., 1930. Variation in the composition of river waters. Int. Rev. d. g. Hydrobiol. u. Hydrogr. **24**:47-80.

6. Cunnington, W. A., 1920. The fauna of the African lakes: A study in comparative limnology with special reference to Tanganyika. Proc. Zool. Lond. **1920**:507-622.

7. Denham, S. C. (To be published.)

8. Duclaux, J., 1912. La constitution de l'eau. Rev. Gen. Sci. **23**:881-887.

9. Eddy, S., 1934. A study of fresh-water plankton communities. Illinois Biol. Mon. **4**:1-93.

10. Eigemann, C. H., 1896. Turkey Lake as a unit of environment, and the variation of its inhabitants. Proc. Indiana Acad. Sci. **1895**:204-216.

11. Forbes, S. A., 1887. The lake as a microcosm.

12. Migula, W., 1888. Die Verbreitungsweise der Algen. Biol. Centbl. **13**:514.

13. Moore, J. E. S., 1903. The Tanganyika problem. London.

14. Naumann, E., 1928. Das limnological Laboratorium in Aneboda. Int. Rev. d. g. Hydrobiol. u. Hydrogr. **21**:158-160.

15. Sars, G. O., 1909. Zoological results of the third Tanganyika expedition, 1904-1905. Report on the Copepoda. Proc. Zool. Soc. 1909, **1**:31-77.

16. Scott, W., 1924. The diurnal oxygen pulse in Eagle (Winona) Lake. Proc. Indiana Acad. Sci. **33**:311-314.

17. Sutherland, Wm., 1900. The molecular constitution of water. Phil. Mag. **50**:460-489.

18. Wesenberg-Lund, C., 1908. The plankton investigations of the Danish lakes. Copenhagen.

19. Woltereck, R., 1928. Ueber die Population Friedericksborger Schloss-See von Daphnia cucullata und einige daraus neuentstandene Erbrassen, besondere des Nemi-Sees. Int. Rev. d. g. Hydrobiol. u. Hydrogr. **19**:172-203.

PROGRAM OF THE SECTION ON ARCHEOLOGY

Chairman: ELI LILLY, Indianapolis

Since the section on archeology had been only recently organized, it was not possible to announce a complete program in advance of the meeting. The following papers constituted the complete program.

1. Excavation of the Nowlin Mound. Glenn A. Black, Indiana Historical Society.
2. *Outlines suggesting classification problems. Glenn A. Black, Indiana Historical Society.
3. *Origin and antiquity of the American Indian. Eli Lilly, Indianapolis.
4. Early Pueblo buildings, T. B. Noble, Jr., Indianapolis.

---

*Published in this volume.

OUTLINES SUGGESTING CLASSIFICATION PROBLEMS

Glenn A. Black and Paul Weer, Indianapolis

Classifications of Irregular Geometric Forms

It is a very bold individual indeed who will suggest ideas concerning descriptive methods pointing toward a system for the simplification of classifications for archaeological artifacts. The chief difficulty in the way of arriving at simplified classifications lies in the great diversity of irregular forms. Consequently, the problem becomes so intricate, so full of pitfalls, that one is apt to become lost in a maze of detail out of which there is but slight possibility of gathering together and properly grouping the essentials.

Whether the subject be axes, celts, gorgets, projectile points or any one of the many groups of artifacts, we must recognize at the very start that there are certain forms which almost defy description. This fact has lead us to search for the basic geometric form of a given object, and then, secondly, to describe its deviation or modification from this basic form with the least possible amount of description.

The great need for such a plan made itself first apparent in our work on gorgets. Several hundred of these were re-arranged into the groups and sub-groups of the "International Classification". We were immediately confronted with the spectacle of an appallingly large number of forms that did not fit adequately into the classification: that is, the general classificatory term was not enough to give a proper mental picture of the object. We discovered that this classification inadequacy was due to a lack of proper descriptive terms for the modifications of geometric forms.

Before proceeding with this problem we made a careful search for something entirely new as a method of approach to classification. This finally resulted in confirmation of the geometric nomenclature adopted by Dr. Warren King Moorehead and his committee when the "Internationl Classification" was developed. The knowledge that such a plan as we had in mind should be worked out on the geometric principle led us to present to certain institutions, and to individuals qualified to be helpful, this question: "Is there an Industry or an Art that has developed a classified nomenclature for certain irregular geometric forms which occur both in nature and as the result of man's handiwork?" A very diligent search revealed the fact that no such work had been done, while the general response with the suggestion that it should be done was of surprising interest to us.

With this much behind us, the next step was to let the objects themselves do most of the talking. As we worked with an artifact this thought was always foremost in our minds: How may this object be most briefly described in a manner that will be readily understood by others? This has been a long, gruelling process, but it has had its rewards, for the artifacts themselves have become articulate in showing us similarities in apparent dis-similarities. Through a unified method of describing modifications we gradually began to see greater uniformity in basic forms. The plan as it developed soon outgrew the single problem of gorget forms, for we discovered an inter-relationship between these and other artifact forms whose classifications and descriptions gradually and naturally assumed this new relationship to the modification terms. This, for the very adequate reason that the terms apply to any and all geometric forms wherever they be found, either in nature or as the result of special treatment and change by man. Our work is not final in any sense of the word; and the results are not one individual's observations but rather the accumulated developments and refinements of our co-workers and numerous friends. The process is still going on, for we are continually seeking for fundamental simplicity. The multitude of variant forms have not been allowed to carry us into a highly complicated system, and if we have erred on the side of simplicity, possibly that is a good fault. What we have attempted to do is most certainly subject to friendly and constructive criticism, for we are interested in one purpose only, and that is to make available for our friends and co-workers in Archeology as also for anyone in the Arts and Industries who may have occasion to use it, a generally recognized classificatory nomenclature for irregular geometric forms.

The basic flat geometric forms are the circle, the triangle, and the square: one continuous line, three lines and three angles, four lines and four angles, respectively. Other forms are either combinations or variants of these. Without thought of so doing, and at the very beginning of our work, we automatically dropped the term "variant" and substituted the term "modification". Strangely enough this seemed to be the key to our problem for while so many artifacts were basically rectangular or triangular, the slight modifications worked into the finished objects so altered their forms that to say this was a rectangle, that a triangle, etc., appeared to be a very inadequate and often times incorrect description of the artifact. But there the object was as big as life itself, a modified rectangle or the modification of some other form as the case might be. This situation was met by providing the terms: *Rectanguloid*, meaning rectangular-like; *Trianguloid*, traingular-like, and *Circuloid*, circular like.

This at once indicates a modification of the basic form. In this connection it is important to say that there may be times when it is quite sufficient for the purpose in hand to say that a celt is rectanguloid, a projectile point trianguloid, or a gorget circuloid, as the case may be, and let it go at that. If however, as is generally the case, it is important more fully to describe an artifact, a group of modifying terms which have a definite meaning may be used.

We are of the opinion that the best way to explain these modification terms is to show them in connection with pictorial examples. The greatest diversity of form is probably to be found in the flat gorgets.

Gorgets

There are two methods for saying the things we wish to say, one of which is a general treatise on methods for describing modified geometric forms with the application to groups of objects supplemental thereto. The second method is actually to work out the modifications in terms of a concrete problem, and then, later, by inference, catch the larger picture. We believe this second method is much clearer and less tedious and has the added advantage of very definitely showing the applied terms as they fit a concrete problem. With gorgets we are dealing with types familiar to all archaeologists; and so, without further descriptive background, we are ready to proceed with our problem.

Rectanguloid Forms

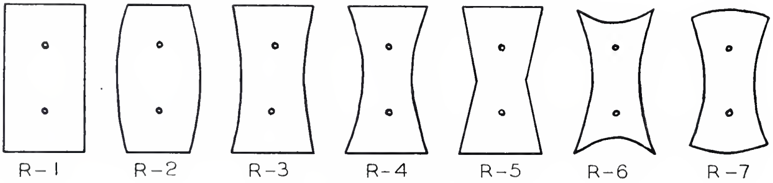


FIG. 1. Rectanguloid forms.

Many so-called rectangular forms are not true rectangles: that is, "having four sides and four right angles." Figure 1, R-1, is a true rectangle or rectangular form, but to describe R-2 we must consider the modification of the sides which do not join the ends at right angles. The word *Rectanguloid*, that is, rectangular-like, conveniently indicates that our figure is a modified rectangle. The slight outward curve of the sides is described as *Excurvate*. Therefore, R-2 is described as *Rectanguloid—sides excurvate.* In R-3 the sides are curved slightly inward; so R-3 is *Rectanguloid—sides incurvate.* R-4 is a well-known gorget form for which there is no need of change with the exception of using the word rectanguloid, thus: *Rectanguloid—sides concave.* It is of interest to note that a figure with convex sides is not shown, for we have discovered a more correctly defining term for this form as will be shown later (E-4). In R-5 the sides are modified not as curves, but with angular lines, therefore R-5 is described as *Rectanguloid—sides constricted.* In R-6 we have concave sides and concave ends, described as *Rectanguloid, Quatre-concave.* R. 7 is *Rectanguloid—sides concave, ends convex.* Here we have the maximum modification to which a rectangle may be subject. It very closely borders on the Panduriform, but is nevertheless most certainly Rectanguloid.

The Elliptical Forms

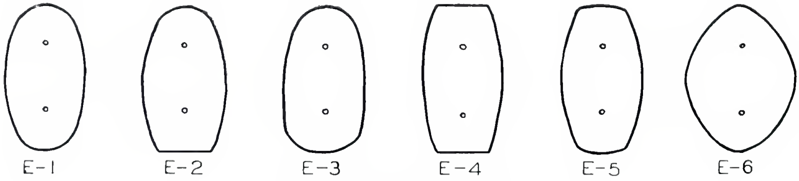


FIG. 2. Elliptical forms.

The curvilinear symmetry of its sides indicates an elliptical form. Figure 2, E-1 represents the elliptical form unmodified. It is simply

Elliptical. In E-2, however, while we have a basically elliptical form, one end has been cut off by a straight line. This, of course, is a truncation; so we suggest describing E-2 as *Elliptical—monotruncate.* If, instead of truncation, one end has been flattened or blunted as in E-3, the term *oblate* exactly describes this modification, and, therefore, E-3 is *Elliptical—monoblate.* If both ends be truncated, as in E-4, we have an *Elliptical—bitruncate* figure. When flattened or blunted as in E-5, it is *Elliptical—bioblate.* There are elliptical forms which approach a circle, as E-6, *Hyper-elliptical.*

The Oval and Ovate Forms

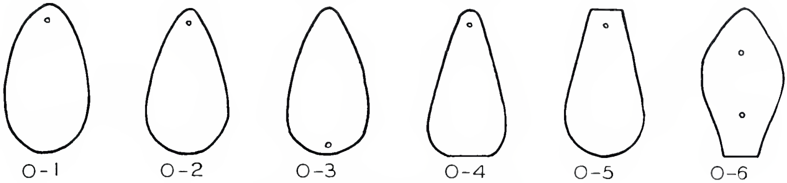


FIG. 3. Oval and ovate forms.

The *oval* form is represented in Figure 3, O-1, and the *ovate* as O-2. Here we are following the distinction in leaf terminology, the oval with its egg-shaped apex, and the ovate pointed at the apiculate end. The perforation in both O-1 and O-2 is at the apex, described as *Apicular perforation.*

The listing of the first three forms follows: O-1, *Oval—Apicular perforation;* O-2, *Ovate—Apicular perforation;* O-3, *Ovate—Basal perforation.* An interesting form widely distributed in nature, and found in several archaeological artifact groups is shown in O-4. Here is a form which deserves special treatment. It is most certainly an Ovate with a truncate base. We discovered that the word *cuneal* (meaning wedge-shaped) as a modifying term to ovate gave us the combination.

Cuneal-Ovate we believe clearly and adequately describes this form. Therefore in describing O-4 we have a *Cuneal-Ovate, apicular perforation.* O-5 is an *oval* or *ovate,* whichever you may wish to call it, with *Truncate apex* and *apicular perforation.* Occasionally there may be such a form as a *Cuneal-Ovate* with *Truncate apex,* but a figure of this nature is usually more correctly described as an *Ovate-Oblong, sides excurvate,* as will be shown in connection with Trianguloid forms. (T-R-4). O-6 is an *Obovate—Truncate base.* Obovate means "reversed egg shape, having the broad end upward or toward the apex." Oblation is not a modification for the oval and ovate forms with the single exception that an Ovate with oblated apex is, of course, an Oval.

There is another fact concerning the oval and ovate forms which should be taken into consideration. Quite often we find artifacts of these forms with bodies, the sides of which for a portion of their lengths are almost straight. In such a case the word *linear—Linear oval,* or *Linear ovate* as may be required, conveys a proper mental picture of this proportional relationship.

The Trianguloid Forms

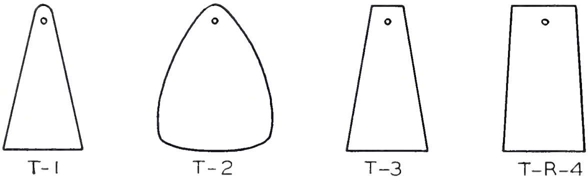


FIG. 4. Trianguloid forms.

Figure 4, T-1 is a regular triangle with apicular perforation. T-2 is the deltoid form of the triangle, and in this figure the two sides and base are excurvate. Therefore T-2 is described as *Trianguloid—Deltoid form tri-excurvate, Apicular perforation.* T-3 is *Trianguloid—Truncate apex Apicular perforation.*

T-R-4 is a very well known and often repeated form among archaeological artifacts. We were able to find a regular dictionary word to describe it, *ovate-oblong.* An ovate-oblong is an oblong having one end broader than the other. In this word-combination, "ovate" is a descriptive adjective. The wider end is the base; the narrow end the top. Therefore it is a rectanguloid form basically; but we have shown it here with the trianguloid forms to emphasize the difference between it and T-3. The ratio of convergence of the sides is the distinguishing feature between T-3, a trianguloid with truncate apex, and T-R-4, ovate-oblong. Once this distinction is noted, there will be very little, if any, confusion between the two forms. Ovate-oblongs which have heretofore been classed as Rectangular caused us much consideration until the term was discovered; and this discovery became one of the first suggestions that these modification terms could be used for other groups: for example, it gave us a new defination for so many celts which we were now able to classify as Ovate-oblong, sides excurvate, elliptical in cross-section.

The Panduriforms

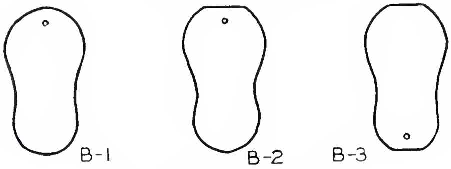


FIG. 5. The panduriforms.

A Panduriform is "an obovate with a concavity on each side, like a violin", "fiddle-shape." There are many large thick gorgets of this form, and, with the reminder that as an obovate the apiculate end is the larger, we have in Figure 5:

B-1, *Panduriform—apicular perforation;* B-2, *Panduriform—truncate apex, Apicular perforation;* B-3, *Panduriform—bitruncate, Basal perforation.*

Pentagonal and Other Several-Sided Forms

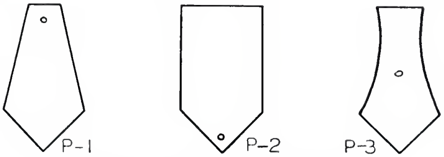


FIG. 6. Pentagonal forms.

Pentagonal-shaped gorgets such as Figure 6, P-1, P-2, and P-3, have usually been classified as shield-shaped. This does not convey a definite picture by reason of the fact that a shield may be any one of many shapes —circular, square, rectangular, elliptical, etc.

In classifying and describing these forms we have taken into consideration the number of sides and the geometric pattern they make. Figure 6, P-1, is pentagonal, made after the pattern of an ovate-oblong whose base has been modified by two lines forming a pointed base.

P-1 is *Pentagonal—Ovate-oblong with pointed base, Perforation at the top.*

Now in P-2 we have a *pentagonal* (five-sided figure) which is *Rectanguloid with one end straight, reverse pointed; perforation at the point.* P-3 is *Pentagonal—ovate-oblong with incurvate sides; base pointed; center perforation.* A variety of modifications may be found in these forms, subject to the terms already outlined. Furthermore, if the figure be six-sided it is hexagonal, the same principle holding for figures having any number of sides, the description indicating the number of sides and the basic geometric modified forms they assume.

Compound Forms

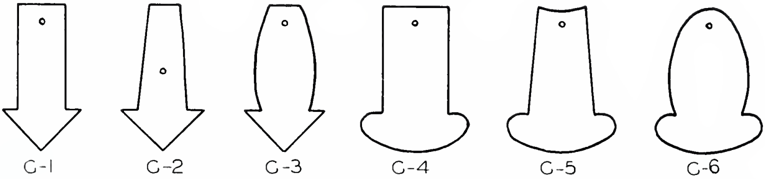


FIG. 7. Compound forms.

Closely following description of a classification plan for pentagonal forms, which indicates the wide range of combinations of modifications which can be briefly and graphically catalogued, we have in Figure 7 a group of compound forms for which it is necessary only to show the application: C-1, *Rectanguloid—1 end forming Sagital point, reverse straight; perforation at straight end;* C-2, *Ovate-oblong—sagittal base, center perforation;* C-3, *Ovate, Truncate apex, sagittal base, apicular perforation;* C-4, *Rectanguloid—1 end forming a lunate, reverse straight; perforation at straight end;* C-5, *Ovate-oblong—lunate base, incurvate top; top perforated;* C-6, *Oval—lunate base, apicular perforation.*

Miscellaneous Forms

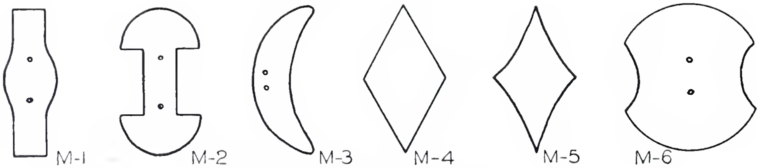


FIG. 8. Miscellaneous forms.

Above (Fig. 8) are illustrated a group of miscellaneous forms which are found in practically all gorget collections. They are classified as follows:

M-1, *Expanded center type, 2 perforations.* No attempt has been made to change the name of this well-known artifact form. M-2.—Attempted classifications of this form have always been rather obscure. We have gone to the bannerstones for a descriptive formula: *Round-wing bipennate tablet, 2 perforations.* M-3, *Lunate, tablet-form, 2 perforations.* M-4, *Rhombus, tablet-form.* M-5, *Rhombus, tablet-form, quatre-incurvate.* If the sides of M-4 or M-5 be of unequal length the forms are *Rhomboids.* M-6, *Circuloid—2 opposing equi-concavities, 2 perforations.*

In the preceeding pages we have outlined a method for gathering together in a classification-plan the modifications found in irregular geometric forms. We have been dealing with two manifestations of the line—a straight line and a curvilinear line. These may be pushed either inward or outward, or cut off, in all of which cases the object which the line or lines bound has been modified, and each line enters into a new relationship with other lines in the same plane. To provide a group of terms to describe these changes and their effect upon the object was our first purpose. This has made it possible, we believe, now to suggest a simplified classification for the group of objects to which these artifacts belong.

We wish to emphasize a suggestion made on a previous page that it may not always be necessary or even advisable to describe all modifications present in an artifact, but when and if this is advisable a method is available. In this connection, it is becoming increasingly more important to show these modifications in archeological literature because we are discovering that slight differences in the form of an artifact often denote widely divergent cultural affinities. The discovery in our workshop that all Adena-type gorgets have counter-sunk perforations to the practical exclusion of that in other types is but a different aspect of the same problem, and has not been neglected in our classification plan.

The Gorget Classification

The Gorget Classification consists of three main divisions: I—Geometric Forms; II—Morphological Forms; III—Culture Forms. The use of the organized group of modification terms we have described makes it possible to describe an artifact as minutely as may be desired. In division II, Morphological Forms, the form and structure of an artifact is so well known that it is not necessary to qualify it unless there be some unusually distinctive modification. For example, the "Expanded Center" gorget is so well known as to form and structure that it is not necessary to describe its geometric form. If the ends of an artifact of this form are incurvate or concave, or if the centrum periphery is oblate, or the flat surface longitudinally ingrooved, it is a matter of individual responsibility as to these matters; but certainly "Expanded Center" gorget conveys the essentials as to the form and structure of this form. Division III, Culture Forms, go a step farther away from a geometric classification, as, for example, Folsom point. It is a culture form, and no description is necessary except as and when modified away from the accepted form. As time goes on and knowledge grows, artifacts will progress from Division I to Division II to Division III, where they will be known in their cultural relationship to other objects.

Classification of Gorgets

I. Geometric forms.
  1. Circuloid
  2. Elliptical
  3. Oval or Ovate
    A. Cuneal Oval or Cuneal Ovate
  4. Rectanguloid
    A. Ovate-Oblong
  5. Trianguloid
  6. Compound
  7. Miscellaneous
    A. Bipennate
    B. Lunate
    C. Unusual
    D. Specialized
    E. Asymmetrical
II. Morphological forms.
  1. Expanded Center
  2. Panduriform
  3. ———
III. Culture forms.
  1. ———

Celts

In dealing with celts we get away from flat objects (that is with rare exceptions) and must consider both outline and cross section. For example, the following will describe literally millions of celts: Ovate-oblong, quatre-excurvate, with rounded corners; elliptical in cross-section. It may be that the classification "Ovate-Oblong" is all that is necessary. If so, well and good. If it is desirable to give additional description it may be done with a minimum of effort and confusion. If to the above description be added the material of which the celt is made and its measurements, a complete mental picture of the artifact is provided.

Before suggesting a classification for celts there are a few things that should be said. First, concerning the descriptive term *rounded corners*. After much effort we have failed to discover anything that so simply conveys the idea. It is a good archaeological term and good geometry. We are not interested in adding anything new that can be avoided. However, the terms *elongate* and *linear* should be fixed. These have particularly to do with elliptical forms and oval or ovate forms. An *ovate*, for instance, may be overly long for its width; this should be described as an *Elongate Ovate*. Or the object may be basically ovate, however, with rather straightish sides; this would be a *Linear Ovate*, conveying the idea of sides (edges) that for a portion of their length are almost straight lines. There are many archeological artifacts, especially among the celts, projectile points, and blades, that must have these modifying terms used if they are to be described with any degree of thought for making their forms visual.

The well-known cross-section descriptive term *1 surface flat, reverse convex*, which applies to so many celts, cannot be improved. We have no suggestions concerning the descriptions of celt "beveling". Nothing that has been done through the arduous years of the past should be lost. We would like to help bring it all together and make it easier to use. The celt classification is basically the same as the gorget classification. If we are to make progress, many of the geometric celt forms will become morphological forms and some may become culture forms as we learn more fully their stories.

Classification of Celts

I. Geometric forms
  1. Elliptical
  2. Oval or Ovate
    A. Cuneal Oval or Cuneal Ovate
  3. Ovate-Oblong
  4. Rectanguloid
  5. Trianguloid
  6. Compound
  7. Miscellaneous
    A. Unusual
    B. Specialized
    C. Asymmetrical

II. Morphological forms.
  1. ———

III. Culture forms.
  1. ———

Blades and Projectile Points

We fully expect and are prepared to withstand much pressure on the subject of suggestions for a simplified classification for blades and projectile points. We are convinced that there is a natural meeting place somewhere between Thomas Wilson's encyclopedic classification and the ultra-practical classifier's division into three groups: triangular, stemmed, and leaf-shaped. As a matter of fact, we do not agree to the latter classification at all, because *triangular* is a morphological form; *stemmed* is not a form at all, but rather a secondary feature to some basic geometric form; and *leaf-shaped* can mean any one of several forms just as did shield-shaped with gorgets.

Generally speaking, "blades" include the larger artifacts, knives, spearpoints, ceremonials, and all forms with two points. As a more or less arbitrary rule, the projectile points are, of course, with one point, and usually under five centimeters in length. This thing of distinguishing between the type names for various forms is very largely a matter of personal judgment and at once suggests an interesting problem—the infinite variety in blade and projectile point forms, from the crudest to the finest of beautiful and intricately worked objects. Three factors governed this: time, the material, and the skill of workman. It is not necessary more than to suggest this, and leave it with the thought that a fine piece of flint, in the hands of a master chipper who had time to do the job, produced a beautiful or useful object. Many a worked flint is neither beautiful nor useful, nor ever was to its original user. Therefore, we suggest a division into three classes: C—Crude, B—Finished, A—Exceptional. It is not always necessary or even advisable to designate a blade or a projectile point as a "C" type or "B" or "A" type, but there are times when this division may be helpful, for example, when working with a large group from one site, or when cataloguing a substantial quantity. This is a class distinction entirely aside from a general classification plan.

Preparatory to presenting our suggested classification, let us say that we have no suggested changes for describing barbs, bevels and serrations. We believe that our three-fold general classification outline adequately covers the requirements for blades and projectile points: I—Geometric forms; II—Morphological forms; III—Culture forms. In describing geometric forms the modification terms shown on earlier pages hold equally true. When a geometric term is used to classify a morphological form, it is something more than simply a geometric term. It implies an archeological background which has given to the term certain very definite connotations, and usually implies more or less general culture affinities which as yet are not specifically determined. Whether the descriptive term be geometric or otherwise, a culture term does indicate a very definite culture alignment.

Returning to the first classification group, geometric forms, we have two main sub-groups: (1) with two points; (2) with one point. In the first we have broken up the term *leaf-shaped* into four classifications using for these the three standard leaf-classification forms:

(1) elliptical, (2) lanceolate, and (3) linear, and adding (4) rhombus (Fig. 9). These forms are subject to the modifications already outlined.

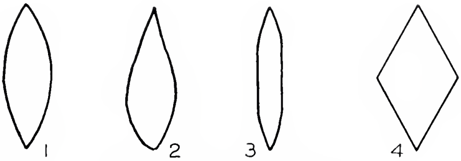


FIG. 9. Two-point forms.

In sub-group 2, with one point, we are convinced there are but two classifications, (1) ovate or oval and (2) trianguloid. We must get hold of something basic. Inasmuch as these objects have one pointed end, we will have an expanding body traveling away from that point, the body bounded by two edges which form straight lines or curved lines or their modifications. The cutting off or boundary of the base is accomplished in the same manner. The modifications have already been described, but with this addition: We must consider that the lines may be affected in a manner peculiar to this special problem, that is, indented or notched. These notches may be: (1) in the sides, *sides notched,* (2) in the edge-base corners, *corners notched,* (3) with the edge-base corners broken off, *corners removed,* (4) in the base, *basal notched,* or (5) with a specialized indentation in the base, *bifurcated.*

We are still endeavoring to classify a modified geometric form, and, inasmuch as the artifact has but one point, it must, basically, be either ovate or oval or trianguloid. This is the case, for if you will pick up at random any blade or projectile point, unless it be an extremely crude "C", an asymmetrical form, or a compound form, you will at once (or after a little practice) see its geometric or modified geometric form. The form of the notches or their placement does not alter the basic geometric form.

We believe that the basal portion of a point is of primary importance as a culture trait. The notches and stem prepared the base for hafting or other uses after the manner of the cultural standards of its user. The notching either did or did not provide a stem; or, by the same token, to provide a culturally correct stem, the notching *had* to be done after a manner effecting this result.

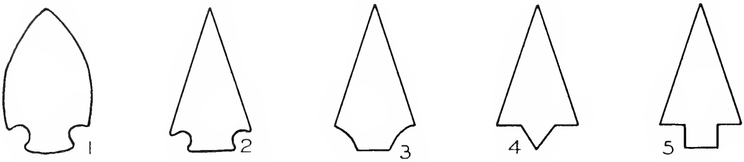


FIG. 10. Specimen forms.

However, merely to classify an artifact as a stemmed point does not tell enough of the story. To say that Figure 10, 1, is an *ovate. corners notched,* automatically conveys the idea of a stem. To say that Figure 10, 2, is *trianguloid, corners notched,* or that Figure 10, 3, is *trianguloid, corners removed,* gives us the picture of stemmed objects, but more, some conception as to their forms.

Now we are stepping on dangerous ground with our eyes open, and lest we be misunderstood, remember there are exceptions to every rule. We believe there are artifacts in which the stem appears to lie outside the geometric figure. For example to say that Figure 10, 4, is *trianguloid, with basal stem* we believe is not only a clearer picture, but also a more correct geometric description, for here we have no need to search further for our geometric form. The question of describing the stem (expanding, straight, or, in this case, contracting to a point) is a matter of individual wishes according to one's own particular ideas. In Figure 10, 5, the straight stem-end suggests *trianguloid, corners removed,* but we believe *trianguloid, with stem* is a truer geometric description. This does not destroy, but rather strengthens, the general plan.

In other words, "stemmed point" is not enough; we must know the picture of the base. We know this is contrary to the historical technic of archeologists, but we are more and more convinced that one cannot tell much about the base until he has an idea of the geometric form of the artifact as a complete object.

We place *Triangular Points* under Morphological forms. Archeologically speaking, a triangular point is more than simply a geometric description. *Folsomoid*[1] is also a morphological form, while *Folsom* is, of course, a culture form.

---

[1] After these pages were written we discovered that the word *Folsomoid* had been used. See: Roberts, Frank H. H., Jr. A. Folsom complex. Smithson. Misc. Coll. 94:7. 1935.

Classification of Blades and Projectile Points

Classes
  C—Crude
  B—Finished
  A—Exceptional
- I. Geometric forms.
  - 1. With two points
    - A. Elliptical
      - a. Hyper-elliptical
    - B. Lanceolate
    - C. Linear
    - D. Rhombic
    - E. Miscellaneous
      - a. Unusual
      - b. Specialized
      - c. Asymmetrical
  - 2. With one point
    - A. Ovate or Oval
      - a. Cuneal-Ovate or Cuneal-Oval
    - B. Trianguloid
    - C. Compound
    - D. Miscellaneous
      - a. Unusual
      - b. Specialized
      - c. Asymmetrical
- II. Morphological forms.
  - 1. Triangular
  - 2. Folsomoid
  - 3. ———
- III. Culture forms.
  - 1. Folsom
  - 2. ———

THE ORIGIN AND ANTIQUITY OF THE AMERICAN INDIAN

ELI LILLY, Indianapolis

The great chief Mishikinakwa, or Little Turtle, one of Indiana's most illustrious sons, when told of the theory that America was originally populated by Asiatics migrating across Bering Strait (**6**, p. 37), immediately asked, like a loyal son of Indiana, why Asia and the rest of the world could not have been populated by Americans!

It is now generally recognized that mankind could not have originated in America because anthropologists of today know definitely that man evolved from the nearer Primates, and the existence of any such forms in America at any time is very doubtful (**16**, p. 485). Since there are many of these species in the Old World, man must have originated there.

It is reasonable to suppose that, considering the limited means of transportation available to primitive man, he could have come only from those parts of the Old World lying closest to America. These portions are the western coast of northern Africa, northwestern Europe, the Polynesian Islands, and northeastern parts of Asia. Within the period of man's existence, geology teaches that there have been no nearer lands than these, with the possible exception of a far northern connection between Asia and America (**16**, p. 488). The never dying fables of lost continents may be dismissed without a hearing, along with the tales of the Ten Lost Tribes of Israel and fictions concerning the Phoenicians and Carthaginians (**31**, p. 220).

An African origin seems out of the question, partly on account of the distance and also the fact that there is so little in common between the Negro and the Indian, who cannot bear the heat of the tropics, perspires little, is easily prostrated at elevated temperatures, and is peculiarly subject to diseases of hot climates, showing none of the immunity of the African (**3**, pp. 34-35). Northern Europe has been occupied by the white race for such a long period that the possibility of invasion from that direction seems remote (**16**, p. 489), and yet there are some points of evidence that lead to the conclusion that some migration came from that quarter. Indeed, the Indians from the eastern and southeastern United States, illustrated in *The History of the Indian Tribes of North America*, by McKenny and Hall, look very European, with oval faces, reddish-brown in color, non-Mongoloid cheek bones, and prominent noses. The representations of the plains Indian show the well-known Mongoloid type; so it seems almost certain that the European cast of countenance of the eastern Indian was not simply the result of artistic license taken by the painter (**14**, p. 153). Are these characteristics the result of European admixture, or do these Indians represent the peripheral fringe of early dolichocephalic arrivals in America *via* Bering Strait, pushed eastward by later Mongoloid peoples?

It has also been pretty well established that the Pacific islands could not have been inhabited previous to the habitation of America (**16**, p. 490). All the islands far enough off the South American coast not to be visible, such as Juan Fernandez and the Galapagos, had never been inhabited prior to the discovery of America (27, p. 267). The supposed likenesses between the houses, the cloaks, and the defensive structures of the Maori and the Northwest coast Indians (4, pp. 321-328) are entirely superficial; so the theory of any connection there is untenable. Domesticated pigs and fowls, widely disseminated in Oceania at the time of discovery, did not exist in America but spread rapidly among the natives after their introduction (27, p. 268). There had been no exchange of cultivatable plants with the possible exception of the calabash, *Lagenaria vulgaris*, about which a verbal battle still continues (27, p. 269-270). While it is not impossible that a few stray mariners afloat on the Pacific may have reached America, it does not seem reasonable to suppose that any great number arrived by that route (14, p. 141). That at least one contact actually did occur has been proved by the finding in South America of a single Maori "patu" in a pre-European, possibly pre-Incaic, grave (4, p. 352).

Turning to northeastern Asia, however, the picture changes. Only about thirty miles separate the two continents at Bering Strait; in clear weather the American highlands are visible from the East Cape of Asia, and in winter ice forms across the strait (18, p. 28). Another route might have traversed, the Bering Sea by way of St. Lawrence Island, and it is pointed out by Ralph W. Chaney, of the Carnegie Institute of Washington, that this island lay in the pathway of a redwood forest belt which was continuous from North America to Asia in ancient times (33, p. 20). Further south there is still a third course, *via* the long semicircular chain of the Aleutian Islands, which reaches within four hundred miles of Kamchatka, and even that distance is broken nearly into halves by the Commander Islands. This route is possible today with the primitive boats of the natives, but the sea is generally tempestuous, and examinations of the ancient middens and the inhabited sites of the Aleutian Islands do not show that they were a thoroughfare for great migrations (11, p. 34).

The similarity in type of the American Indians to the inhabitants of northeastern Asia and Polynesia is more than suggestive. They have the same range of color; the quality and distribution of hair is similar; they share the same dark brown eyes with moderate slant, the prominent cheek bones, and the posteriorly hollowed upper front teeth. Their similar mentality and behavior speak for their close relationship. Indeed, if a member of one or the other of these peoples were transplanted, and his body and hair dressed in the fashion of those with whom he was surrounded, he probably could not be distinquished physically by any means at the command of a scientific observer (16, p. 489). The American Indian languages resemble structurally a group of three or four dialects in northeastern Asia called the Americanoid languages, though the relationships are not close enough to cause the latter to be placed in the same category as any in North America (2, p. 366). There are similarities in religious ceremonials, beliefs, and traditions. Another feature common to northwestern America and eastern Asia in the use of slat armor of wood, bone, or ivory, and of the sinew-backed bow (2, p. 365), as well as coiled basketry (34, p. 215).

It seems almost necessary that a land bridge should have existed to account for the migrations of animals and plants from one continent to the other, and, while there has been no connection in postglacial times, it is very probable that during the Wisconsin stage of glaciation the sea must have been so low, owing to the accumulations of the ice on the land, that a land bridge did exist (18, p. 31).

As to possible routes of early migration, a broad belt east of the Rockies, through the Mackenzie River Valley and extending southward, was uncovered at an early date, possibly twenty-five or thirty thousand years ago. Conditions in the Yukon Valley also may have been favorable for a long period. These western routes have probably been open much longer than those in northeastern North America by way of Hudson Bay, Labrador, or the Gulf of St. Lawrence (18, pp. 44-45).

The remains of Pleistocene mammals are found in Alaska, the Cordilleras, and to the southeast, as well as in Mexico and Central America. In eastern Canada they are found very rarely. These facts seem to point to the probability of their ingress from Asia and have an important bearing upon the migrations of early man, who would very naturally have followed and hunted these animals (18, p. 32).

It is also a modern conception that the climate during at least one of the interglacial periods was as warm as or warmer than the present climate of North America. Near Toronto, Ontario, interglacial deposits have been found containing many specimens of trees that we have today, namely, red cedar, pawpaw, hickory, osage orange, oak, elm, and maple (18, pp. 25-26). It follows that the climatic conditions were as favorable to migration, for Quaternary mammals or early man, as these conditions are at present.

Man cannot be supposed to have reached the colder northeastern limits of Asia before the warmer and richer parts of that continent were settled or hunted over, but the theory is plausible that from the exhaustion of resources or the incursion of enemies they gradually were forced toward the East Cape (16, p. 490). Climatic change was a chief cause back of the migrations of archaic man, as it was for the large herds that he followed (15, p. 125). The northeastern portion of the Asiatic continent was never fit, in man's time, to support a large number of human beings (16, p. 492). The hunting tribes were forced farther northward and eastward for existence, until at last they began the great adventure into America. These primitive migrations from Asia could not have been the result of a fixed plan and were not confined to any one period. They continued, wave upon wave, for thousands of years, the latest being perhaps that represented by the Eskimos in the northwesternmost part of America (23, pp. 29-30). Quite likely there were rediscoveries of the New World by various routes, and the dribbling over very probably continued from the arrival of the first parties to the historic period, when Eskimos were found to be trading across St. Lawrence Island and Bering Strait (16, p. 493).

These ages witnessed the building up and tearing down of a multitude of cultures, some advanced and others archaic, and they also saw an outstanding diversification of languages. "Thus from out of the mist of an almost inconceivable past, the wraithlike outlines of the earliest races of America come into view, but very faintly. Then the dust of the ages falls upon and covers them. Unrecorded and unnamed, like the substance of a dream, they have past and left no sign (33, p. 20)." During these many years great changes had come about, changes in climate, and, consequently, in flora and fauna, and changes among the tribes. Certain of them in Central and South America advanced to civilizations comparable to those existing in Egypt and Mesopotamia two thousand years before Christ (17). Certain groups had retrograded, and new tribes were forming from overpopulated centers, drawing off into new territories, driving others before them and afterwards becoming the nucleus for further development and modification.

In considering these migrations it is natural to think of them as almost impossible for primitive man to carry out, but we are quite apt to underestimate greatly the territory covered by Indians in their travels. For example, when Tecumtha and his agents were trying to rally the Indian nations to protect their lands, they covered the entire country from the Seminoles of Florida to the tribes of the Missouri River. The Iroquois of central New York were familiar with the Black Hills of Dakota. They went to South Carolina to attack the Catawba and marched against the Creeks in Florida. "Western Indians traveled hundreds of miles to obtain blankets from the Pueblos and some plains Indians are known to have traveled two thousand miles on raids. . . . They (the Indians) had covered the entire continent with a network of trails over which they ran long distances with phenomenal speed and endurance; the Tarahumare mail carrier from Chihuahua to Batopilas, Mexico, runs regularly more than five hundred miles a week; a Hopi messenger has been known to run one hundred and twenty miles in fifteen hours" (25, p. 735). DuPratz (7, pp. 122-129) living with the Natchez in the sixteen hundreds talked with an old Indian who had made one trip to the mouth of the Columbia River, Oregon, and another to the Atlantic Ocean and Niagara Falls!

The racial relations of the American aborigines with the inhabitants of the Old World have been most ably summed up by Dr. E. A. Hooton (12, pp. 361-362):

> Briefly, then, my present opinion as to the peopling of the American continent is as follows: At a rather remote period, probably soon after the last glacial retreat, there straggled into the New World from Asia by way of the Bering Straits, groups of dolichocephals in which were blended at least three strains: one very closely allied to the fundamental brunet European and African long-headed stock called 'Mediterranean'; another a more primitive form with heavy brow-ridges, low broad face and wide nose, which is probably to be identified with an archaic type represented today very strongly (although mixed with other elements) in the native Australians, and less strongly in the so-called 'Pre-Dravidians' such as the Veddahs, and also in the Ainu; thirdly an element almost certainly Negroid (not Negro). These people, already racially mixed, spread over the New World carrying with them a primitive fishing and hunting culture. Their coming must have preceded the occupation of Eastern Asia by the present predominantly Mongoloid peoples, since the purer types of these dolichocephals do not show the characteristic Mongoloid features.
>
> At a somewhat later period there began to arrive in the New World groups of Mongoloids coming by the same route as their predecessors. Many of these were probably purely Mongoloid in race, but others were mixed with some other racial element notable because of its highbridged and often convex nose. This may have been either Armenoid or Proto-Nordic (or neither one). These later invaders were capable of higher cultural development than the early pioneers and were responsible for the development of agri-

culture and for the notable achievements of the New World civilization. In some places they may have driven out and supplanted the early long-heads, but often they seem to have inter-bred with them, producing the multiple and varied types of the present American Indians—types which are Mongoloid to a varying extent, but never purely Mongoloid. Last of all came the Eskimo, a culturally primitive Mongoloid group, already mixed with some non-mongoloid strain before their arrival in North America.

The working out of the distribution of the racial types in America is a most complex and interesting and unsolved problem. If all the peoples entering America came through the bottle neck of Alaska, it is reasonable to suppose that the first comers would travel or be pushed to the remote marginal areas (**14**, p. 142). In many parts of the New World, brachycephals are superimposed stratigraphically upon dolichocephals (**14**, p. 143), and in the more remote parts of South America, very primitive strains of non-Mongoloid long-heads are evident.

It is quite certain that the earliest new-comers to America were primitive in the extreme. Successive waves were probably in various stages of culture, but it is almost certain that none had passed beyond the hunter-and-fisher stage or had developed anything like a sedentary social system. It is now generally believed that all developments toward higher culture made by the Indians were accomplished by their own efforts, with no outside help (**23**, p. 30). The biological-agricultural evidence wholly supports the theory of an autochthonous development of the pre-Columbial civilization in America (**24**, p. 382).

There has not yet been found conclusive proof that man existed in the New World prior to the last glacial period, although a number of artifacts and human skeletal remains have been brought to light, suggestive of great antiquity. Among these are discoveries made by Dr. Abbott near Trenton, New Jersey (**3**, p. 27), finds in Nebraska (**1**, p. 70), and the Argillite culture described by Skinner and Spier (**8**, p. 264). At Conklin 9 Cave, New Mexico, and in Gypsum Cave, Nevada (**29**, p. 79), and in an ancient lake bed near Las Vegas (**10**, p. 48), remains of extinct species of mammals were found in association with those of man. Certain well-authenticated discoveries of arrow points with the remains of extinct species of bison are on record, none more celebrated than the finds at Folsom, New Mexico (**29**, p. 79), and at Dent, Colorado (**28**, p. 7). The Minnesota Man discovered in 1931 was found buried in a deposit which geologists say is 20,000 years old (**10**, p. 50). The Punin skull, found embedded in volcanic ash in the Andean region of Ecuador along with the bones of the extinct horse, camel, and mastodon, caused Sir Arthur Keith to say (**15**, p. 133), "The discovery at Punin does compel us to look into the possibility of a Pleistocene invasion of America by an Australoid people." The ground sloth probably was still in existence when man reached South America (**29**, p. 78). At Melbourne, Florida, human remains are definitely present in the same deposits with a large number of extinct mammals, although the geological evidence points to a fairly late date for the formation of these beds, probably not further back than ten or twenty thousand years (**29**, p. 79). The artifacts found with the bones of extinct animals are apparently always of the types called Folsom, Folsom like, or Yuma (**15**, p. 149), and, while it may be dangerous to draw too positive conclusions, these types resemble quite closely those of Solutrean Europe (**15**, p. 136).

These finds do not prove the great antiquity of man in America, for the conception that many of these extinct forms have lingered on to within a few thousand years or less is gaining ground. This may possibly have been caused by the north and south direction of American mountain chains, furnishing a safe migration corridor for use during great changes of climate (15, p. 75). A vast amount of extinction has apparently taken place since the recession of the last ice sheet, which is most difficult to explain unless, indeed, the cause be man himself, which is hardly probable (29, pp. 76-77). To sum the whole situation up, however, until man-made objects or human remains are found in an admittedly undisturbed Pleistocene stratum, the antiquity of man in America will remain an unsettled problem (13, p. 563).

A few years ago a new criterion appeared upon the scene which held out great hope of solving the racial origin problem, namely, the blood grouping of a people. The American Indians belong almost entirely to group O, having practically no agglutinogens in the blood. The Blackfeet and Blood Indians of Canada appear to be among the few exceptions to this rule being high in A (22), while the Caraja Indians of South America rate high in B (9).

The blood groupings of the Mongoloid peoples are, strange to say, very different from this. The north Chinese, north Koreans, and Manchus are high in B and low in A, while the south Chinese, south Koreans, and Japanese are high in A and moderate in B (30, p. 247).

This difference between the blood groupings of the American Indians and their closest racial relatives would seem to indicate that their separation occurred before the A and B mutations appeared. The western Eskimos in America are high in B, while all other Eskimos are largely of the O group, showing possibly that the western Eskimos were the last to come into America after having been modified by the mongoloids of North China. It is interesting to note that all peoples having more than fifty per cent of their individuals in the O grouping are isolated peoples like the Philippinos and the American Indians. It is thought by some scientists that agglutinogen A did not originate much before the Christian era (12, p. 354), but their theory has received a rude jolt from the work of Landsteiner and Miller, who have apparently demonstrated the factors A and B in anthropoids. If this be true these agglutinogens must have origniated prior to the development of present-day man (30, p. 250). The blood-grouping theory of the relationships of races will have to be further developed before it will be of much help in solving the American Indian problem.

Even the lowly louse has contributed his share of evidence for the folk passages across Behring Straits. Ewing secured hair samples from some twenty pre-historic American Indian mummies. Lice were found in all—those from Peru little different from those of the southwestern United States. While the evidence is not beyond question, it has been shown that the head lice of the Chinese and Eskimos of the Aleutian Islands are quite similar to the insects discovered by Ewing (35, p. 26).

In speculating upon the length of time that the Americas have been inhabited by man, it is well to remember that upon discovery they were settled from one end to the other by a population variously estimated at from five million to fifty million. These inhabitants had been there long enough to have become completely adjusted to the change from arctic to tropic conditions, from sea level to the highest habitable altitudes, to have established tribal boundaries, and to have produced twenty-three separate culture centers. Industries had been developed—irrigation, metallurgy, architecture, sculpture, ceramics, textiles, and a real agriculture.

Three hundred and sixty-eight tribal groups had been developed, varying in organization from the anarchy of the Eskimo to the League of the Iroquois, and from the military theocracies in Central America to the communistic despotisms in Peru (**26**, p. 97).

It is believed that in the United States and Canada there were six hundred dialectic groups, four hundred for Mexico and Central America, and eight hundred in South America (**34**, p. 177). During the time elapsed since the discovery, there has been very little change in the Indian and Eskimo languages. This affords some idea of the length of time necessary for such changes (**27**, p. 253).

The lengths to which scientists go in attempting to determine the relative lengths of time that the Eastern and Western Hemispheres have been inhabited by man may be indicated by the following: the ratio of iron meteorites found is 79 for the Eastern Hemisphere as against 182 in favor of the Americas, while for stone meteorites the ratio is reversed. These theorists argue that as a natural result of longer occupation the valued metallic objects have been used up (**26**, p. 124).

Then again, the shell heaps or kitchen middens of the New World do not approach in thickness those of the Old World. The extreme depth of shell heaps in America is probably in the neighborhood of forty feet, while at the Anau Kurgan sites in Russian Turkestan, the rubbish rose to a height of one hundred seventy feet, and a mound at Susa in southern Mesopotamia was found to be at least one hundred feet thick (**26**, pp. 107-108).

Whatever the racial origin of the American Indian, he has been on these continents long enough to have received a Mongoloid "wash" which made the whole of America "akin," and to develop cultures and characteristics which are fundamentally similar, such as the methods of working with stone, clay, bone, and wood, weaving and basketry, the construction of homes, the making of clothing and fire, agriculture, ideas of medicine and religion, games, folk lore, social organizations, and conceptions of nature. The behavior of all Indians is much the same in their family and tribal relationships and in their ceremonies, songs, warfare, and other activities (**16**, p. 482).

The constitution of the Indian is much the same everywhere. Although not exceptionally strong, he has physical endurance. He is little subject to degenerative diseases, such as cancer, cretinism, insanity, etc., but is an easy prey to alcohol, and is affected quickly by tuberculosis, measles, smallpox, and syphilis (**16**, p. 482).

All this leads to the strong presumption that the advent of man in America came at about the end of the last glacial period, or, putting it in years, from ten to fifteen thousand years ago. In the early post-glacial period the climate was so cold that the reindeer grazed as far south as Kentucky, while the mammoth, the giant sloth, and the peccary found pasturage in the upper Ohio and Delaware Valleys (3, p. 23). Recent competent criticism (**32**, p. 87) has concluded that legends of the mammoth told by certain northern tribes are "historical traditions rather than mere myths of observation or recent Causasian introductions."

For some reason or other the red race built up its highest cultures in Mexico and Peru. In Peru the wonderful weaving of the Incas rivaled the Gobelin tapestries, and their surgery was far advanced. The Mayas had astronomical observatories and had worked out a better calendar than any used in other parts of the world. Their sculpture and architecture were well developed, and in mathematics they had conceived the zero several centuries before the Arabs and while the British Isles were a wilderness (**21**, pp. 5-14).

Cortez says in his second letter to Charles V (**20**, p. 263): "I will not say more than that, in the service and manners of the people, their fashion of living was almost the same as in Spain, with just as much harmony and order; and considering that these people were barbarous (and this from Cortez!), so cut off from the knowledge of God, and other civilized peoples, it is admirable to see what they attained in every respect!" Of the residences of Montezuma, he writes (p. 265): "So I limit myself to saying that there is nothing comparable with them in Spain."

In pottery, the American Indian excelled, and among the ceramic forms that he used, may be found most of those created by the natives of all other parts of the earth (**27**, p. 287).

As to agriculture, it is well to dwell upon the thought that the economic might of the United States rests upon maize, long-fiber cotton, potatoes, rubber, beans, tomatoes, and tobacco—our heritage from the Indians (**31**, p. 246).

Even in the Pueblo region of the United States, a great population existed, organized on a pacific basis, living in great apartment houses, and approaching the civilization of Mexico in their arts (**21**, p. 11). From these centers of development the influences faded out toward the northern borders of North America to the wild tribes of the North. We should always remember that (**21**, p. 15): "There was as great a gap between a Sioux warrior and a Maya astronomer as there was between an English swineherd of the seventeenth century and Galileo."

In the field of mechanics, the New World was not without its developments and discoveries, for example, the suspension bridge of the Andes, the hammocks of South America, the ventilation shafts of the Kivas, the bolas, and possibly the snowshoe of the North (**34**, p. 185).

What a fascinating speculation it is to wonder what these people would have accomplished if they had not been destroyed by the Europeans! What if they had continued to develop, their cultures being cross fertilized by migration, conquest, commerce, and travel? But never, alas, was a less developed civilization struck such an overwhelming and stunning blow from a greatly overpowering force, than when Europeans invaded America.

Another peculiarity of the early inhabitants of the Americas is the almost complete disassociation of the peoples of the two continents. It is known that the first peoples to migrate from North America into

South America were very primitive—without agriculture, pottery, metals, or stone celts. They probably wore clothing made of skins and used coiled basketry; some had bows and stone-tipped arrows and others had none (27, p. 259). There is no language common to South and Central America except that of the Arawak, whose migrations through the Antilles to Florida probably did not long antedate the discovery (27, p. 253). Many other elements of culture were decidedly different, and not a single object of Central American or Mexican manufacture has ever yet been found in South America (27, p. 292). It is probable, however, that, just before the discovery, coastwise trade brought the knowledge of metallurgy to Mexico from South America (27, p. 294).

It is evident from the foregoing that anything like an accurately dated history of the American aborigines is out of the question in the present state of our knowledge. Archeologists and historians, however, have been able to work out the chronology of the most civilized portions of the Americas since about 1500 to 1000 B. C., and the following chart will give a rough idea of the time relationships of the civilization of the areas of southwestern United States, Mexico, and the Andean region (28, pp. 4, 5; 23, p. 47).

	Southwestern United States	Central America	Andean Area	
1500 or 1000 B.C.	Basket Maker Period	Archaic and Introductory	Archaic and Migratory	
0				
100			*Highlands*	*Coast*
200		Old Empire of Mayas and Northwardly Expansion in Yucatan	Advanced Archaic or Tiahuanoco I Period	Early Chimu and Nazca Culture
300	Pueblo I			
400				
500				
600				
700				
800	Pueblo II		Tiahuanoco II Empire	
900		1st Period of Decline		
1000			Decline	
1100*a*				
	Pueblo III	New Empire		
1200				
b			Early Incas	Late Chimu and Nazca
1300		Toltec Period		
1400				
a				
1500	Pueblo IV	Second Decline	Inca Empire Empire	
1600				
b				
1700				
Present	Pueblo V			

It is estimated that not much more than two thousand years should have been necessary for the highest American culture to have risen from a primitive agricultural status. This conclusion is arrived at largely by comparison with early Old World cultures. Crete rose and fell in about twenty-six hundred years; Egypt in approximately three thousand years; and the Sumarian civilization rose and declined between 5000 and 2000 B. C. (**12**, pp. 352-353). If that time is chosen as approximately correct (and it must be acknowledged that no discoveries of cultures, in any way extensive, in America can be proven conclusively to have antedated 1500 or 2000 B. C.), then there is an hiatus of ten or twelve thousand years between that date and the closing of the latest glacial period that still remains to be accounted for. During just how much of this period the gradual infiltration of man into America was taking place is still a matter of theory and conjecture.

The development of civilization in Central America and Mexico is a fascinating study, filled with romance, and one that causes us to wonder again about the reason for the development and dissolution at certain times and in certain places of centers of human culture! What happy combination of circumstances brought about the first great Maya empire? And why did it collapse along about 700 A. D.? Was it a change of climate, or exhaustion of the soil, or was the population swept away by yellow fever or some other pestilence? This apparently, was followed by a great period of recovery and a second empire from 1000 to 1200 A. D., which was probably brought to an end by invasions of Mexican tribes from the north (**31**, p. 239), ending with Toltec rule and bringing the great Quetzalcoatl. The archeological finds of this period include gold figurines from Colombia and Costa Rica and turquoise exchanged with tribes of New Mexico for parrots, some of which were ceremonially buried at Pueblo Bonito and other ruins in the Southwest (**31**, p. 241).

From Central America as a center spread the cultivation of maize, beans, tobacco, and cotton, the use of the bar loom, the painting of pottery, the erection of pyramidal structures, and the cult of human sacrifice (**34**, p. 212).

The culminations of civilization in these areas seem to have been in Peru about 800 A. D., in the Maya area 1000 A. D., and in our own Southwest about 1200 A. D. It may be found yet that the mound area with its strange pottery development flourished at about that same time or a little later (**34**, p. 175).

The population of North and South America at 1200 A. D. has been estimated by Spinden at about fifty million (**34**, p. 176). At the time of early white contact, the population was densest, of course, in Mexico and the Andean highland. In North America north of Mexico the most thickly populated localities were the western coast, the eastern gulf states, and the northeastern states, with an especially densely settled spot in the Pueblo region. Florida, the Carolinas, and the Great Lakes region came in for a good quota, while the great central plains and especially the cold north were rather sparsely settled (**19**, p. 5).

References

1. Bell, Earl H., 1934. An evaluation of recent Nebraska finds sometimes attributed to the Pleistocene. Wisconsin Archaeologist, Vol 13.

2. Boas, Franz, 1933. Relationships between North-west America and North-east Asia. The American Aborigines. Toronto.

3. Brinton, Daniel H., 1901. The American race. Philadelphia.

4. Dixon, Roland B., 1933. Contacts with America across the southern Pacific. The American Aborigines. Toronto.

5. Dorsey, H. W., 1932. Chief Clerk Smithsonian Institution, letter dated August 25.

6. Dunn, Jacob P., 1919. Indiana and Indianans, Vol. 1. New York.

7. Du Pratz, M. Le Page, 1763. The history of Louisiana, Vol. 2. London.

8. Goddard, Piny Earle, 1927. Facts and theories concerning Pleistocene man in America. American Anthropologist, Vol. 29.

9. Golden, Gerald, 1930. Distribution of blood groups in South American Indians. Lancet 2:278.

10. Guthe, Carl E., 1935. North America. Amer. Archaeological Ser. Pan American Union, Washington, D. C.

11. Holmes, W. H., 1919. Problems of intercontinental communication. Bur. of Amer. Ethnol., Bul. 60.

12. Hooton, Earnest Albert, 1930. The Indians of Pecos Pueblo. New Haven, Conn.

13. Hooton, Earnest Albert, 1932. Up from the ape. New York.

14. Hooton, Earnest Albert, 1933. Racial types and their relations to Old World types. The American Aborigines. Toronto.

15. Howard, Edgar B., 1935. Evidence of early man in North America. Journ. Museum Univ. Pennsylvania, Vol. 24.

16. Hrdlicka, Ales, 1925. The origin and antiquity of the American Indian. Ann. Rep. Smithsonian Inst., 1923.

17. Jenness, Diamond, 1933. Preface, The American Aborigines. Toronto.

18. Johnston, W. A., 1933. Quaternary geology of North America in relation to the migration of man. The American Aborigines. Toronto.

19. Kroeber, A. L., 1934. Native American population. Amer. Anthropologist Vol. 36.

20. MacNutt, Francis Augustus, 1908. In Fernando Cortez, his five letters of relation to the emperor Charles V. Vol. 1. Cleveland.

21. Mason, Gregory, 1931. Columbus came late. New York.

22. Matson, G. A. and H. F. Schroder, 1933. Blood grouping among the Blackfeet and Blood Tribes of American Indians. Journ. of Immunology 25:155.

23. Means, Philip Ainsworth, 1931. Ancient civilizations of the Andes. New York.

24. Merrill, E. D., 1931. The phytogeography of cultivated plants in relation to assumed Pre-Columbian Eurasian-American contacts. Amer. Anthropologist, Vol. 33.

25. Myer, William E., 1928. Indian trails in the Southeast. Ann. Rept. 42. Bur. Amer. Ethnol. 1924-1925.

26. Nelson, N. C., 1933. The antiquity of man in America in the light of archaeology. The American Aborigines. Toronto.

27. Nordenskiold, Erland, 1933. Origin of the Indian civilizations in South America. The American Aborigines. Toronto.

28. Roberts, Frank H. H. Jr., 1931. The ruins at Kiatuthlanna, Eastern Arizona. Bur. Amer. Ethnol., Bull. **100.**

29. Romer, Alfred S., 1933. Pleistocene vertebrates and their bearing on the problem of human antiquity in North America. The American Aborigines. Toronto.

30. Snyder, Laurence H., 1927. Blood groupings and its practical application. Archives Pathol. and Lab. Medicine, Vol. 4. Chicago.

31. Spinden, H. H., 1933. Origin of civilizations in Central America and Mexico. The American Aborigines. Toronto.

32. Strong, W. D., 1934. North American Indian traditions suggesting a knowledge of the mammoth. Amer. Anthropologist, Vol. **36.**

33. Thompson, Edward Herbert, 1932. Perple of the serpent. New York.

34. Wissler, Clark, 1933. Ethnological diversity in America and its significance. The American Aborigines. Toronto.

35. Zinsser, Hans, 1935. History and the louse. Atlantic Monthly (January).

PROGRAM OF THE SECTION ON BOTANY

Chairman: A. R. BECHTEL, Wabash College

1. *Additional algae of the lower Wabash Valley. M. E. Britton and B. H. Smith, Indiana State Teachers College.

2. *Post-Pleistocene fossil records in peat of the upper Blue River Valley, Henry County, Indiana. J. E. Potzger, Butler University.

3. The occurrence of multicellular root hairs in Bryophyllum calycinum. Arthur Guard, Purdue University.

4. Genetic experiments in Late Spencer sweet peas. William J. Tinkle, Taylor University.

5. *Myxomycetes of Clark County, Indiana. William D. Gray, University of Pennsylvania.

6. *Notes on plasmodial behavior of Stemonitis fusca. William D. Gray, University of Pennsylvania.

7. Effect of precipitation and annular growth in Quercus. Arnold Kleine, J. E. Potzger and Ray Friesner, Butler University.

8. Physical data bearing on the type of relicts illustrated by Pinus Strobus and Tsuga canadensis in Indiana. Ray C. Friesner and J. E. Potzger, Butler University.

9. Fagus-Acer vs. Quercus-Carya as forest climax in Indiana. R. C. Friesner and J. E. Potzger, Butler University.

10. *Additions to the vascular flora of Jasper County, Indiana Winona H. Welch, DePauw University.

11. *Plant boreal relics in Indiana. Winona H. Welch, DePauw University.

12. Applications of photography to some problems of teaching and research. Paul Weatherwax, Indiana University.

13. The status of the Dutch elm disease in the United States. John N. Porter, Purdue University.

14. Sterilization of corn grains with sodium hypochlorite. Raymond E. Girton, Purdue University.

15. *Notes on plants of Jefferson County, new or rare in Indiana. Edna Banta, Bloomington.

16. *Some preliminary studies in soil pasteurization. R. B. Zumstein, Purdue University.

17. *Algae of Indiana. Third list of additions to the 1875-1928 check list. C. Mervin Palmer, Butler University.

18. *A fungus contaminating shaving cream. C. L. Porter and J. N. Porter, Purdue University.

19. Photoperiodism in some tropical grasses. Paul Weatherwax, Indiana University.

20. Modification of vascular tissue in midvein of Quercus alba leaves induced by gall development by Cynips pezomachoides erinacei. E. Fay Kenoyer, Butler University.

21. A bryocenological study of some epiphytic mosses of a central Indiana woods. Betty T. Wilson, New Albany.

22. A new genus of Phycomycetous fungi. George Zebrowski, Buck Creek.

23. *Notes on Indiana Grasses. J. E. Potzger, Butler University.

24. *Note on a seedling variation in sunflower. C. A. Ludwig, Washington, D. C.

Papers No. 22, 23, 24 were read by title.

---

*Papers published in this volume.

ADDITIONAL ALGAE OF THE LOWER WABASH VALLEY

M. E. Britton and B. H. Smith, Indiana State Teachers College

This report, made up primarily of algal forms collected in Posey and Gibson Counties, is presented by the writers as an addition to two previous reports of Lower Wabash Valley algae. Although the majority of the forms listed are from the two counties mentioned above, a few forms from other counties have been added. These latter forms have been identified from collections of 1932.

All forms listed from Posey and Gibson Counties were collected on a one-day trip to the extreme southwestern section of the State. Considerable difficulty was experienced by the writers in obtaining algal material in this section of Indiana, because of the hard rains of the early spring and summer months. Every body of water of consequence was visited in Posey County, but with little success. The most valuable materials collected, especially the Oedogoniaceae, were found in roadside ditches and small, shallow bodies of water. Hovey's Lake and Half Moon Pond, two of the largest bodies of water in Posey County, were found to be barren of algae. Surface samples taken with the plankton net in Hovey's Lake were practically devoid of algal forms.

The same methods of collection, preservation and identification were used as described in previous papers. The preservation solution used was Transeau's solution of water, alcohol, and formaldehyde in the ratio of 6:3:1.

The writers are reporting a total of 36 species and varieties. Of these, eleven species and one variety have not been previously reported from Indiana. Two species, *Oedogonium crispum*, variety *hawaiense* Nordstedt, and *Oedogonium lageniforme* Hirn., have not been previously recorded in published reports from the United States. All other forms are new for the counties listed.

ALGAE SYSTEMATICALLY ARRANGED

Class I—Myxophyceae

Order—Chroococcales

[1]*Aphanocapsa rivularis* (Carm) Rabenhorst. Gibson Co., July 5, 1935.

[4]*Merismopedia punctata* Meyen. Gibson Co., July 5, 1935.

[4]*Merismopedia tenuissima* Lemmerman. Posey Co., July 5, 1935.

Class V—Chlorophyceae

Order—Volvocales

[4]*Eudorina elegans* Ehrenberg. Posey Co., July 5, 1935.

[4]*Pandorina morum* Bory. Posey Co., July 5, 1935.

[4]*Volvox mononae* G. M. Smith. Posey Co., July 5, 1935.

---

[1] Species—not previously reported from state.

[2] Variety—not previously reported from state.

[3] Genus—not previously reported from state.

[4] Genus or species or variety—not previously reported from county.

[5] Species—not previously reported from United States.

Order—Chlorococcales

[2]*Pediastrum integrum* var. *priva* Printz. Posey Co., July 5, 1935.

[4]*Coelastrum cambricum* Archer. Parke Co., September 14, 1932.

[4]*Crucigenia crucifera* (Wolle) Collins. Posey Co., July 5, 1935.

[1]*Oocystis elliptica* W. West. Sullivan Co., July 5, 1935.

[4]*Scenedesmus bijuga* (Turpin) Lagerheim. Posey Co., July 5, 1935.

Order—Ulotrichales

[4]*Ulothrix zonata* (Weber and Mohr) Kuetzing. Posey Co., July 5, 1935.

Order—Oedogoniales

[1]*Oedogonium areolatum* Lagerheim. Posey Co., July 5, 1935. Previously reported from Iowa and Ohio. Measurements of oogonia and oospores slightly smaller than those recorded by Lagerheim.

[4]*Oedogonium borisianum* (Le Clerc) Wittrock. Posey Co., July 5, 1935.

[1]*Oedogonium crenulatocostatum* var. *aureum* Tilden. Posey Co., July 5, 1935.

[1]*Oedogonium crispum* var. *gracilescens* Wittrock. Posey Co. July 5, 1935.

[5]*Oedogonium crispum* var. *hawaiense* Nordstedt. Posey Co., July 5, 1935. Previously reported from Hawaii.

[4]*Oedogonium globosum* Nordstedt. Posey Co., July 5, 1935.

[5]*Oedogonium lageniforme* Hirn. Posey Co., July 5, 1935. Oospore filling lower part of oogonium in most cases. Previously reported from Brazil.

[4]*Oedogonium plagiostomum* Wittrock. Vigo Co., August 28, 1932.

[4]*Oedogonium pringsheimii* var. *nordstedtii* Wittrock. Posey Co., July 5, 1935. Oospore slightly smaller than those recorded by Wittrock. Vegetative cells more nearly answer the description of var. *abbreviatum*.

[1]*Oedogonium rugulosum* Nordstedt. Posey Co., July 5, 1935. Epiphytic on Oedogonium and Bulbochaete.

[4]*Oedogonium varians* Wittrock and Lundell. Posey Co., July 5, 1935.

Order—Zygnemales

[1]*Spirogyra articulata* Transeau. Vigo Co., 1935.

[1]*Spirogyra tetrapla* Transeau. Vigo Co., 1935.

[4]*Zygnema insigne* (Hassall) Kuetzing. Vigo Co., 1935.

[1]*Zygnema subcruciatum* Transeau. Vigo Co., 1935.

Order—Desmidiales

[4]*Closterium ehrenbergii* Menegh. Posey Co., July 5, 1935.

[1]*Closterium lunula*. Posey Co., July 5, 1935.

[4]*Closterium moniliferum* (Bory) Ehr. Posey Co., July 5, 1935.

[4]*Euastrum verrucosum* var. *alatum* Wolle. Posey Co., July 5, 1935.

[4]*Hyalotheca dissiliens* (Smith) De Brebisson. Posey Co., July 5, 1935.

[4]*Penium margaritaceum* (Ehren.) De Brebisson. Posey Co., July 5, 1935.

[4]*Pleurotaenium maximum* (Reinsch) Lund. Gibson Co., July 5, 1935.

[4]*Pleurotaenium trabecula* (Ehrenb.) Nag. Gibson Co., July 5, 1935.

[1]*Staurastrum pusillum* Wolle. Vigo Co., September 19, 1932.

Bibliography of Indiana Records for Counties Mentioned

Andrews, F. M., 1926. A list of algae of Monroe County, Indiana, II. Proc. Ind. Acad. Sci. **36**:223-225.

——————., 1929. Algae of Monroe County, Indiana, III. Proc. Ind. Acad. Sci. **39**:57-58.

Britton, M. E. and Smith, B. H., 1933. Some algae of the Lower Wabash Valley. Proc. Ind. Acad. Sci. **42**:45-46.

——————., 1935. Further studies of Indiana algae. Proc. Ind. Acad. Sci. **44**:65-68.

Love, L. M. and Rogers, R. L., 1933. Some algae of Vigo, Greene, and Daviess counties. Proc. Ind. Acad. Sci. **42**:79-81.

Palmer, C. M., 1929. Algae of Indiana: a classified check list of those published between 1875-1928. Proc. Ind. Acad. Sci. **38**:109-121.

——————., 1931. Algae of Indiana: additions to the 1875-1928 check list. Proc. Ind. Acad. Sci. **40**:107-109.

——————., 1932. Plankton algae of White River in Marion County and Morgan County, Indiana. Butler University Botanical Studies. **2**: 125-131.

——————., 1933. Algae of Indiana: second list of additions to the 1875-1928 check list. Proc. Ind. Acad. Sci. **42**:90-91.

Smith, B. H., 1932. The algae of Indiana. Proc. Ind. Acad. Sci. **41**:177-206.

Tiffany, L. H., 1930. The Oedogoniaceae, a monograph including all known species of the genera Bulbochaete, Oedocladium and Oedogonium. Columbus, Ohio.

White, H. L., 1931. The phytoplankton of a solution pond, with special reference to the periodicity of certain algae. Proc. Ind. Acad. Sci. **40**:123-140.

POST-PLEISTOCENE FOSSIL RECORDS IN PEAT OF THE UPPER BLUE RIVER VALLEY, HENRY COUNTY, INDIANA

J. E. Potzger, Butler University

The records of past ages in the area now comprising Indiana are extensive and unique. They represent almost the entire range of life on earth from the earliest Paleozoic, whose exposure is due to the Cincinnati Arch, to the more recent Pleistocene deposits. Trilobites and brachiopods cemented into limestone speak of vast seas which once rolled over these now elevated land masses, and the coal age with its abundant records of plant remains is well represented in the southwestern part of our state. But in more recent times the Pleistocene not only left a trail of tell-tale relic colonies of northern plants here in Indiana (1, 2), but also made its contributions to the fossil records by depositions in bogs and slowly-forming topographic features, where life records are neatly stored away as in a vast archive, preserving the story of the day when they were living forms, and linking the past to the present, partially interpreting for us the plant and animal world of today.

In spite of the valuable information which these records can and do give us, in spite of the fact that these records are irreplaceable, Indiana has done little to preserve them. The economic phase superseded scientific importance, and so we drained, ditched, excavated, blasted, burned, and ripped out page after page of the most significant ancient history, in many instances not even making a written record of the message.

It is the aim of this paper to place on record and describe a fast-vanishing post-Pleistocene fossil storehouse in the valley of the upper Blue River in Henry County, Indiana.

Topographic Features of the Region

The Pleistocene has left its characteristic topographic forms and features on the greater part of Indiana, but nowhere are they more obvious and pronounced than in the eastern central part of the state. The rolling topography reminds of the lake states, and the wide valleys excavated in the glacial drift speak of the work of powerful streams. One of these streams was Blue River in Henry County. The half-mile-wide valley is everywhere bordered by high uplands or rounded hills composed of transported soil; drift fifty to two hundred feet in depth covers the bedrock; the landscape is strewn with abundant huge granite and quartzite bowlders (3). The present small stream appears grotesquely lost in the massive valley. One can readily follow the serpentine winding of this ancient river-bed for miles along Highway 3 between Newcastle and Mount Summit. About two miles east of Mount Summit, Highway 36 descends a steep sand and gravel ridge into Blue River Valley, which is now almost entirely under cultivation. Peat soil covers the valley from two to six feet deep and by its black color becomes a striking feature of the landscape. At the present time the river flows in a deep trenched channel excavated by man. The dredging lowered the water table of the adjacent land so that the area could be used for agriculture. If one continues about three miles northeast along Blue

River, the valley suddenly expands into the circular outline of an ancient lake with shore lines sharply marked by high ridges and knolls. When civilized man first came to Henry County, this ancient lake was a wet swamp into which numerous springs drained. It is situated on a watershed and forms the source of two streams, viz. Blue River draining to the south and Buck Creek draining to the north. The head of Blue River was a powerful bubbling spring, but at the present time the source has been tiled and is hidden from view.

Climatic and Vegetational History

What has been said thus far might well be considered a geology report, but, after all, topographic features and their history form the background and screen upon which gigantic dramas of life were enacted and may themselves be the result of such life activity. It is in topographic features that life left its silent evidence which we call fossils, and from such fragments of once powerful life communities the botanist attempts to piece together the life of the past and the part it played and still plays in present-day vegetation. And so we see here in Henry County, now a peaceful farm community, records of Arctic rigor, slowly moving sheets of scouring, gouging, grinding masses of ice, depositing huge amounts of gravel, sand, and clay, deeply covering the landscape with transported soil.

The scenes change, the climate moderates, the ice masses melt and discharge torrential streams of water, which wind their way down the watershed, excavating deep valleys through the kames and moraines. But our interests as botanists lie in another scene of this great drama enacted on soil which is now Indiana.

Climate ever had its expression in plant life and so we can read into the mute remains of a former vegetation the changing climatic conditions and the accompanying succession of vegetation in central-eastern Indiana. Quite frequently we must rely upon fossil pollen to tell the vegetational succession, but we have actual tree remains to record the story in Henry County. True, the obliterating hand of civilized man has blurred the picture somewhat by disturbing the orderly deposits of great vegetations, but we can even now after more than a century of human activity salvage sufficient fossil records to write a chapter on former vegetation in the Blue River Valley. The tree forms of northern forests, Thuja and Larix, lie in huddled heaps in the protecting peat which fills the valley basin, and with it are the accumulations of animal remains, including such large forms as mastodon, deer, and elk.

The Story of Early Settlers

In work of this kind one naturally turns first to the reports of the early settlers, those of our times who have been a vital part in the transformation of a region from a primitive condition to the present farm community. Fortunately in the present case, there are still several old settlers living who can give word-of-mouth report on what the area was like during the dawn of civilization. One of these men is Mr. John Ritchie. Eighty-two years have passed since first he saw the light of the world in Blue River Valley, here he was also destined to spend most of his long life on his father's farm which adjoins the river valley. His father was one of the earliest settlers among the pioneers who came to the region in 1820. At that time the valley floor was intermittent lowland forest and sedge-covered flats, locally and in some geology reports (3) erroneously called prairies. In fact, the region about Mount Summit is called Prairie Township. The settlers called the sedges "saw grass". The whole valley was infested with rattlesnakes which would coil up on the hummocks of the sedges.

The settlers soon claimed the peaty soil of the broad valley, at least in the less wet areas, for agriculture. About forty years ago the river channel was dredged, and the plow soon made an end of the sedges. The farmers were amazed at the abundant cedar deposits embedded in the peat, which they would plow out after the frost had raised them in the cultivated areas. The plowers would at times strike piles of these trees which appeared as deposited in the backwash of a turbulent stream. some of the trees were sixty feet and over in length, with branch and root stubs still intact. Some of the wood was used for fence posts and some for firewood. Mr. Ritchie says that many of the fence posts have served forty years and are still in good condition. Mingled with the cedar logs were trunks of *Larix laricina.* No evergreens were in the valley when the settlers first moved into the region.

Besides these immense drifts of timber, the farmers would then find, and still do find, large numbers of deer and elk antlers. Some of these had parts of the skull attached, and in some instances bones of the whole skeleton were found. Wagonloads of such antlers were sold to the junk dealers. One immense set of elk antlers measured six feet from tip to tip. Mr. James Hernly, another of the old settlers along the valley, found a fine set of mastodon teeth. Well-preserved mastodon teeth and jaws were also found in the valley of Flat Rock River.

Fossil Specimens

Upon the invitation of Mr. Chas C. Deam, the writer accompanied him to the region for closer survey of the soil and fossil remains. Mr. Deam had visited the valley for some preliminary survey work in 1919. On our trip in December, 1934, we found in an uncultivated field old cedar stumps still partially covered by soil with the roots intact, some of these were pulled up and are stored at Butler University. At the farm of Mr. Tom Razor, a block was sawed from a cedar log eleven inches in diameter. A specimen of Larix was collected on the same farm in 1919. While no fine specimens of antlers are available at the present time, residents near the valley offered their cooperation for collection of good specimens which might be found in the future.

The soil is typical peat, and farmers dare not burn corn stalks or brush on the land, for the soil catches fire readily. In some instances such muck fires have smouldered for weeks. Samples of the peat were sent to Dr. Paul B. Sears, of the University of Oklahoma, for analysis. He describes it as moss peat with some sedge remains, but not of sphagnum origin.

The mastodon tusks found by Mr. James Hernly weighed eight pounds each. The tusks, as well as the recently discovered mastodon jaw and teeth, are at present in the Henry County museum at Newcastle.

Relic Boreal Plants in the Region

The only relic boreal plants found by the author are *Potentilla fruticosa* L. and *Gentiana crinita* Froel., which grow abundantly in a little hillside bog above the lake in Memorial Park, a mile north of Newcastle. The plants were first collected there by Mr. Scott McCoy of Indianapolis. They were found nowhere else in the valley, but the region has been so much disturbed by agricultural activity that relic plants possibly existing in 1820 might well have been exterminated since that time. Mr. Chas. C. Deam reports the following additional relic northern plants from that region: *Cacalia tuberosa* Nutt., *Solidago ohioensis* Riddle, *Lobelia Kalmii* L., *Eleocharis rostellata* Torr., *Rynchospora capillacea* Torr.

Discussion

The one species of wood found in the peat is without doubt Larix, for it still bears all characteristics of Larix, and was identified as such by Prof. Record of Yale University, in 1919. The cedar, which the farmers call "red cedar", is not so definitely identified. It has even been suggested that it might be *Juniperus virginiana*, but the fact that stumps of this species were found in the soil with roots in position argues against Juniperus, for the soil is bog substratum, the habitat of Thuja and not of Juniperus. The sapwood in the sample collected is thin, and the freshly-cut wood has a distinct cedar-oil odor.

The question now arises, are we dealing with driftwood deposits where glaciers carried in the remains of northern conifers as well as the carcasses of deer and elk, or are we dealing with a post-Pleistocene cedar-tamarack bog which was superseded by other vegetation in natural succession? The logs found inbedded in the deeper strata of glacial sand and gravel encountered in well digging were evidently brought in by the water, but the logs and antlers found near the surface are imbedded in peat soil covering the glacial sand and gravel. Peat is residual soil, formed *in situ* by plant remains, and must be of post-Pleistocene origin. It is also not likely that the logs could have been washed down after the melting of the ice, for they would hardly have resisted decay if exposed to the air during the time the peat formed in the boggy valley. Besides, even today we find stumps with root remains in the soil.

No doubt the once powerful Blue River dwindled in water volume as the glaciers retreated, and the shallowing outer reaches evidently supported aquatic and helophytic vegetation which gradually filled up the shallow water. Mosses invaded, and in time the valley developed into a cedar-tamarack bog as one sees along most streams in northern Michigan and Wisconsin today. The total absence of these northern species when settlers moved in at the beginning of the last century and the sedge control in the valley indicate pyric influence at a time when Thuja and Larix had been reduced to a relic colony by advancing broad-leaved forest.

The animals might have perished at the same time, but it is more likely that they became mired, and the remains accumulated in the course of time after the forest had disappeared; or the Indians might have driven them into the soft boggy soil and from points of vantage shot them as they made their way with difficulty. Mr. Ritchie found the remains of four posts in the valley placed in a way to indicate the former presence of an elevated platform for lookout purposes.

Destruction of an isolated forest by deep burning in a peat substratum would prevent re-establishment of relic species and initiate a sedge-meadow stage of succession. This was being superseded by willow-ash-elm when cultural influences interfered.

There is a unique sequel to such an hypothesis along Indian River in Cheboygan County, Michigan. According to Mr. R. T. O'Reilly, an old settler of Alanson, Michigan, this river was closely bordered by luxuriant cedar-tamarack forest when, twenty-five years ago, a fire swept through the area and completely destroyed the forest. Three years ago the author visited the region and found the wide belt along the river, once vegetated by cedar and tamarack, a mud flat controlled by helophytic vegetation.

In conclusion: All evidence gathered on repeated visits indicates that the valley of the upper Blue River was once a cedar-tamarack bog in which logs became embedded as they fell, and that a catastrophic influence during a time when the northern forest had been reduced to a relic colony was responsible for the total destruction of these boreal species.

Summary

1. Record is made of a rich post-Pleistocene fossil deposit in peat in the valley of the upper Blue River in Henry County, Indiana.
2. The fossils consist of both plant and animal remains.
3. The logs are, to all appearances, remains of Thuja and Larix.
4. Indications are that they represent the remains of a former cedar-tamarack bog in the valley.
5. Thuja and Larix were not present in the area when settlers moved in at the beginning of the last century.
6. Peat two to six feet in depth covers the floor of the valley.
7. The boreal relic plants found in the area by the author are *Potentilla fruticosa* and *Gentiana crinita*.
8. In 1820 the valley was in the sedge-meadow stage.
9. Animal remains found are a set of mastodon tusks and deer and elk antlers.
10. It is suggested that fire might have been the immediate cause for the complete destruction of the northern forest and the initiation of a sedge-meadow.
11. Relics found in the area will be presented to the State Museum.

Acknowledgments

The writer is deeply indebted to all who gave information and assistance in gathering data for the paper.

Bibliography

1. Friesner, R. C. and J. E. Potzger, 1932. Studies in forest ecology I. Factors concerned in hemlock reproduction in Indiana. Butler Univ. Bot. St. 2:133-144.

2. Ibid., 1932. Studies in forest ecology II. The ecological significance of Tsuga canadensis in Indiana. Butler Univ. Bot. St. 2:145-150.

3. Phinney, A. F., 1886. Henry County and portions of Randolph, Wayne and Delaware. Indiana Dept. Geol. and Nat. History, Ann. Rept. 15:97-116.

MYXOMYCETES OF CLARK COUNTY, INDIANA

WILLIAM D. GRAY, University of Pennsylvania.

The Myxomycetes, a group of plants of approximately four hundred species of world-wide distribution, and commonly known as slime-moulds, include many species which exhibit characters that are of considerable scientific and popular interest. On the one hand, at certain periods of their life cycle they show features allying them with certain lower forms of animal life, while at other periods they have definite plant-like characters. To the layman, the bright color of some species and the delicate make-up of the fruiting structures often prove of great interest. Too often, however, because of their commonly small size and the inconspicuous coloration of many species, they escape the notice of many professional botanists as well as others.

Different species show a considerable range in habitat preference, although a favorable habitat for many species appears to be very rotten logs in cool, damp woods. Some species may be found on grass, rotten leaves, soil, or cinders, and in one instance fruiting specimens of *Stemonitis fusca* were collected on the painted ceiling of a dairy. Certain species, e. g., *Physarum cinereum* and *Lycogala epidendrum*, appear to prefer one type of habitat, while others such as *Fuligo septica* grow equally well in a variety of habitats.

The first reference to myxomycetes in Indiana which I have been able to find was made by Underwood **(1)**, who, in 1893, listed twenty-one species from Putnam, Vigo, and Vermillion counties, those from Vermillion County having been collected by Arthur; he followed this with a report **(2)** of three additional species in 1894. In 1897, Olive **(3)** reported forty-three species from the region about Crawfordsville; this list included thirty species which had not been formerly recorded by Underwood. Thomas **(4)**, in 1900, recorded thirty species from the same region, twenty of these being reported for Indiana for the first time. In 1901, Whetzel **(5)** described in considerable detail seven species of *Stemonitis* occurring in Indiana and accompanied the descriptions with a key to the species and some notes on plasmodial behavior; among the seven species were *S. pallida* and *S. axifera*, which had not been hitherto reported for the state. In the same year Mutchler **(6)** listed thirty-eight species which he had collected in the vicinity of Bloomington, adding nine to the state list; later, in 1902, he presented a second report **(7)** on an extensive collection which was, in the main, obtained near Winona Lake. By this second list Mutchler added twenty-nine to the known species of Indiana myxomycetes. In 1909, Barbazette **(8)** listed fifty-three species based on collections of J. A. Niewland in 1905; of these, thirty-four were collected in Indiana, and five species were new ones for the state. During the years 1911 to 1934, the late Professor J. M. VanHook **(9, 10, 11, 12, 13, 14, 15, 16)** reported various species to this academy at irregular intervals in conjunction with his reports on Indiana fungi. He included forty-one species of myxomycetes in these various papers, adding five to the state list, which raised the total number of species reported for Indiana to one hundred and twenty-four.

None of these reports contained records of any species of myxomycetes collected in Clark County; in fact, Monroe was the southernmost county in the state from which species had been reported. Clark County, particularly that region along the Ohio River, presents many favorable habitats for myxomycetes. In addition to woods along the Ohio, favorable localities are also to be found along Silver Creek, Fern Creek (Fourteen Mile Creek), and Lacasagne Creek. So far, the most fruitful locality has been in the Arctic Springs region (two miles east of Jeffersonville).

This work, which was started at DePauw University in 1933, represents collections made during the past three summers. Undoubtedly more extensive search will reveal many species not included in this report. Specimens herein referred to are deposited (with the same numbers under which they are listed here) at the Herbarium of DePauw University, Greencastle, Indiana. Doubtful specimens were referred to Dr. G. W. Martin, State University of Iowa. Species marked with an asterisk are those being reported for Indiana for the first time.

Subclass EXOSPOREAE

Ceratiomyxa fruticulosa (Muell.) Macbr.

On rotten locust tree in conjunction with sporangia of *Hemitrichia stipitata;* woods near C. C. C. & St. L. yards (Jeffersonville), June 15, 1933 (No. 69). On rotten log, Arctic Springs, June 19, 1935 (No. 103).

Ceratiomyxa fruticulosa (Muell.) Macbr. var. *arbuscula.*
(Berk. & Br.) Macbr. & Martin.

On rotten log in woods near C. C. C. & St. L. yards (Jeffersonville), June 20, 1935 (No. 105).

Subclass MYXOGASTRES

Arcyria cinerea (Bull.) Pers.

On rotten log, Arctic Springs, June 5, 1933 (No. 35); June 16, 1933 (No. 28); June 16, 1934 (No. 106); June 5, 1935 (No. 42). On rotten log, Armstrong Bend, June 19, 1933 (No. 57); in conjunction with *Hemitrichia stipitata*, June 19, 1934 (No. 109). Common in early summer.

Arcyria denudata (L.) Wettstein.

On rotten logs, Arctic Springs, June 16, 1934 (No. 50); July 19, 1934 (Nos. 95 and 96); July 23, 1934 (Nos. 3 and 4); June 19, 1935 (No. 29). On rotten stump, Jeffersonville, June 18, 1935 (No. 45).

Arcyria digitata (Schw.) Rost.

On rotten log, Arctic Springs, June 19, 1933 (No. 38). On rotten locust log in woods near C. C. C. & St. L. yards (Jeffersonville), June 20, 1935 (No. 2).

Arcyria insignis Kalch. & Cooke.

On rotten log near main spring, Arctic Springs, June 30, 1933 (No. 6); on cinders, June 30, 1933 (No. 58).

Badhamia utricularis (Bull.) Berk.

On rotten tree along Fourteen Mile Creek, about 3 miles below Beaver Hole, June 23, 1935 (No. 54).

Comatricha aequalis Peck.

On rotten log in damp ravine, Arctic Springs, July 18, 1935 (No. 91).

Comatricha irregularis Rex.

On rotten elm stump in woods near Lacasagne Creek (3 miles N. E. of Jeffersonville), June 20, 1933 (No. 65).

Comatricha laxa Rost.

On rotten log in damp ravine, Arctic Springs, July 19, 1934 (No. 98).

Comatricha longa Peck.

On rotten sycamore log about one mile below Beaver Hole (Fern Creek), June 23, 1935 (No. 55).

Comatricha typhoides (Bull.) Rost.

On rotten log, Arctic Springs, June 19, 1935 (No. 33); July 18, 1935 (No. 92).

Cribraria microcarpa (Schrad.) Pers.

On rotten log in woods near Arctic Springs, June 26, 1935 (No. 82).

Dictydium cancellatum (Batsch) Macbr.

On rotten log, Arctic Springs, June 19, 1933 (No. 40); July 23, 1934 (No. 62). On rotten log in woods about one mile n. of Memphis, June 8, 1935 (No. 107).

**Dictydium cancellatum* var. *purpureum* Macbr.

On rotten log, Arctic Springs, June 16, 1933 (No. 67); June 16, 1934 (No. 13).

Diderma hemisphaericum (Bull.) Rost.

On rotten oak leaf, Arctic Springs, June 19, 1933 (No. 41).

Fuligo septica (L.) Weber.

On rotten tree stump, Jeffersonville, June 18, 1935 (No. 44).

Hemitrichia stipitata (Massee) Macbr.

On rotten log in woods near C. C. C. & St. L. yards (Jeffersonville), June 15, 1933 (No. 47); in conjunction with *Ceratiomyxa fruticulosa*, June 15, 1933 (No. 69); June 15, 1934 (Nos. 32 and 66). On rotten log in damp ravine, Armstrong Bend, June 19, 1933 (No. 60). On rotten log in drift pile, Fern Creek (3 miles below State Road 62), June 23, 1935 (No. 53). On rotten log, Arctic Springs, Sept. 9, 1934 (No. 110); in conjunction with *Comatricha typhoides*, July 28, 1935 (No. 92).

Hemitrichia vesparium (Batsch) Macbr.

On bark of fallen tree, Tunnel Mill Reservation, April 14, 1933 (No. 56).

Lamproderma arcyrionema Rost.

On rotten log in damp ravine, Arctic Springs, July 18, 1935 (No. 102).

Lycogala epidendrum (L.) Fr.

On rotten ash tree, Arctic Springs, June 23, 1933 (No. 87).

Lycogala exiguum Morgan.

On rotten ash tree in woods near C. C. C. & St. L. yards, June 15, 1934 (No. 31). On rotten log, Arctic Springs, June 26, 1935 (No. 80).

Physarum cinereum (Batsch) Pers.

On living grass in City Hall lawn, Jeffersonville, August 25, 1933 (No. 5). The entire fructification covered a circular area approximately one foot in diameter.

Physarum globuliferum (Bull.) Pers.

On rotten log, Arctic Springs, Sept. 19, 1933 (No. 83); Sept. 19, 1934 (No. 85).

Physarum nucleatum Rex.

On rotten log in woods near C. C. C. & St. L. yards (Jeffersonville), June 20, 1935 (No. 1).

Physarum nutans Pers.

On rotten log, Arctic Springs, June 19, 1935 (No. 43); July 18, 1935 (No. 90).

**Physarum pulcherrimum* Berk. and Rav.

On rotten log in woods about 1 mile n. of Memphis, June 18, 1935 (No. 108). On rotten log, Arctic Springs, July 18, 1935 (No. 101).

Physarum viride (Bull.) Pers.

On rotten log, Arctic Springs, June 19, 1933 (No. 39); June 19, 1934 (No. 97); June 19, 1935 (No. 84); July 18, 1935 (No. 94). On rotten elm stump in damp woods near Lacasagne Creek, June 20, 1933 (No. 59). Common.

Stemonitis axifera (Bull.) Macbr.

On rotten ash tree, Tunnel Mill Reservation, June 14, 1933 (No. 14). On rotten log, Arctic Springs, June 16, 1934 (No. 12).

Stemonitis fusca Roth.

On fallen oak leaves in woods about 1 mile N. of Memphis, June 18, 1935 (No. 104).

Stemonitis pallida Wingate.

On rotten limb in Junior High School yard, July 14, 1934 (No. 26). On rotten log, Arctic Springs, July 18, 1933 (No. 61); July 18, 1935 (Nos. 88 and 100).

Stemonitis smithii Macbr.

On rotten log, Arctic Springs, June 19, 1933 (No. 36); June 20, 1933 (No. 7); July 18, 1935 (No. 89). On rotten elm stump in woods near Lacasagne Creek, June 20, 1933 (No. 30).

Stemonitis splendens Rost.

On rotten log in damp ravine, Arctic Springs, July 18, 1935 (No. 99).

Trichia favoginea (Batsch) Pers.

On rotten elm stump in woods near Lacasagne Creek (three miles n. e. of Jeffersonville), June 20, 1933 (No. 16).

Acknowledgments

The writer wishes to thank Dr. Winona H. Welch, who originally suggested this problem, Dr. Truman G. Yuncker, for invaluable criticisms of the manuscript, and Dr. G. W. Martin for checking doubtful species.

Literature Cited

1. Underwood, Lucien M., 1894. Report of the Botanical Division of the Indiana State Biological Survey. Proc. Ind. Acad. Sci. **1893**:13-67.

2. Underwood, Lucien M., 1895. Report of the Botanical Division of the Indiana State Biological Survey for 1894. Proc. Ind. Acad. Sci. **1894**:144-153.

3. Olive, E. W., 1898. A list of the Mycetozoa collected near Crawfordsville, Indiana. Proc. Ind. Acad. Sci. **1897**:148-158.

4. Thomas, M. B., 1901. Cryptogamic collections made during the year. Proc. Ind. Acad. Sci. **1900**:121-123.

5. Whetzel, H. H., 1902. Notes on the genus Stemonitis. Proc. Ind. Acad. Sci. **1901**:261-266.

6. Mutchler, Fred, 1902. A collection of Myxomycetes. Proc. Ind. Acad. Sci. **1901**:291-292.

7. Mutchler, Fred. Myxomycetes of Lake Winona. Proc. Ind. Acad. Sci. **1902**:115-120.

8. Barbazette, L., 1909. Tentative list of Myxomycetes of northern Indiana and southern Michigan. The Amer. Midl. Nat. **1**:38-43.

9. VanHook, J. M., 1912. Indiana Fungi. II. Proc. Ind. Acad. Sci. **1911**:347-354.

10. VanHook, J. M., 1916. Indiana Fungi. III. Proc. Ind. Acad. Sci. **1915**:141-148.

11. VanHook, J. M., 1921. Indiana Fungi. V. Proc. Ind. Acad. Sci. **1920**:209-214.

12. VanHook, J. M., 1922. Indiana Fungi. VI. Proc. Ind. Acad. Sci. **31**:143-148.

13. VanHook, J. M., 1924. Indiana Fungi. VII. Proc. Ind. Acad. Sci. **33**:233-238.

14. VanHook, J. M., 1926. Indiana Fungi. IX. Proc. Ind. Acad. Sci. **35**:233-236.

15. VanHook, J. M., 1930. Indiana Fungi. XII. Proc. Ind. Acad. Sci. **39**:75-83.

16. VanHook, J. M., 1935. Indiana Fungi. XIII. Proc. Ind. Acad. Sci. **44**:55-64.

NOTES ON PLASMODIAL BEHAVIOR OF STEMONITIS FUSCA ROTH

WILLIAM D. GRAY,[1] University of Pennsylvania

So far as can be determined from available literature on Myxomycetes, little attention has been paid to the interesting phenomena of structural and color changes which accompany the development of sporangia from the mature plasmodium. Some references are made to the color changes which occur in the plasmodia of various species, but the changes which take place in the development of the sporangia are generally not described. The genus Stemonitis is an example of one in which comparatively little is known concerning the plasmodia. Of the seventeen species which belong to this genus, there are only eight of which the plasmodia are known. In a genus so difficult taxonomically as is Stemonitis, every feature of each species should be known if possible. The following is a report of such changes as have been observed to take place in the development of *Stemonitis fusca* from plasmodium to mature fruiting structures.

The plasmodium of *S. fusca*, a pearly-white, tubercular mass, was collected at 3:00 p. m., November 2, 1933. It was found on the lower side of a rotting ash log in a ravine about one and one-half miles west of Greencastle, Indiana. The plasmodium was elliptical in outline, measured 2.0x2.5 cm., and was approximately 5 mm. thick.

The plasmodium, together with a portion of its substratum, was taken immediately to the laboratory, placed on a glass plate, and covered with a large beaker which was sealed to the plate with vaseline. A small dish of water was enclosed under the beaker to provide sufficient moisture for the growth of the plasmodium. During the daytime, the plasmodium received natural light from a north-facing window, and artificial light from a seventy-five-watt electric lamp. With only one exception, when the temperature fell to 12°C. for a few hours, the temperature of the laboratory remained at approximately 19°C. Under these conditions, fructification was completed in eighty-nine hours. The following summary shows the changes that took place:

8:30 a. m. (Nov. 3): A portion of the plasmodium had moved from the side to the upper surface of the block of wood, and differentiation had begun. Sessile sporangia, each with a bulbous enlargement at the top, were discernible. The color of the sporangia was still pearly-white. No stipes were as yet evident.

12:30 p. m. (Nov. 3): Purplish-black stipes (2.5-3.0 mm. in length) had developed. The sporangia had developed to a length of 4.5-6 mm. and were faintly tinged with pink. As at the time of the preceding observation, each sporangium was capped with a small bulbous enlargement. None of the plasmodium proper remained.

5:15 p. m. (Nov. 3): The bulb at the top of each sporangium had disappeared, the color was pale lavender, and the stipes had increased in length to about 6.0 mm. The total height of the sporangia (which were very moist with drops of water clinging to the almost black stipes) varied from 12 to 14 mm. The sporangia were closely aggregated with the outermost members of the group curving toward the center, thus giving the cluster a rounded appearance at the top.

---

[1] Graduate student in Botany, DePauw University, when these observations were made.

7:30 a. m. (Nov. 4): The sporangia had become very dark brown to almost black in color. No changes in size or general form of structure had occurred since the preceding observation. The sporangia were still coherent because of their damp condition. During the preceding night the temperature had dropped to 12°C., but no reaction to the lower temperature was evident.

8:00 a. m. (Nov. 6): The fructification was completed, the stipes were shiny black, and the sporangia had become rich chocolate brown. The sporangia, spores, capillitium, and capillitial net showed no deviation from those of a naturally developed fructification of this species.

The question as to whether or not each species exhibits individual features during fructification can be answered only when many observations have been made. Macbride and Martin (1, p. 162) state that the plasmodium of *S. fusca* passes from white through blue and black, which color changes differ from the observed color changes outlined above. Whetzel (2, pp. 261-266), working with another species, *S. splendens*, observed that the fructification passed from the pearly-white plasmodium through purple-black, dark brown, light brown, and finally, with the shedding of the spores, purple-brown. Undoubtedly, further observations on this species, as well as additional ones, will lead to interesting comparative results, which may, in a measure, serve to aid in the separation and identification of members of this difficult genus.

Aside from its possible taxonomic value, the color changes accompanying the changes from plasmodium to fruiting structures are also of some interest physiologically. Seifriz and Zetzmann (3, pp. 175-179, Pl. III), working with the yellow plasmodium of *Physarum polycephalum*, which they have long cultured, have found the plasmodial color to be due to a yellow pigment, which, they suggest, belongs to the group of respiratory ferments known as flavones, lyochromes, or flavins. These workers have found that the yellow pigment is an acid-alkaline indicator, have calibrated the pigment as a pH indicator, and have found that the plasmodium undergoes changes ranging from pH 8, when fruiting, to pH 1.6 (possibly 1.2), when a sclerotium is formed. The latter finding well fits, and more or less partially substantiates the ideas of the late Professor Macbride (4, p. 22), who placed the order Physarales as lowest in the sequence of orders and inferred that the retaining of lime to the last by the plasmodium was indicative of lower rank. Whether or not the color changes observed in *Stemonitis fusca* are due to the presence of an acid-alkaline indicator must be determined by further work, which is, of course, hindered by the difficulty in obtaining plasmodia of this species. If Macbride's idea is the correct one, and an indicator is present in *Stemonitis fusca*, it is to be expected that at time of fruiting the plasmodium would exhibit a somewhat lower pH than that exhibited by *Physarum polycephalum*.

Acknowledgments

The writer is indebted to Dr. Truman G. Yuncker, DePauw University, and Dr. William Seifriz, University of Pennsylvania, for their criticisms in the preparation of the manuscript.

Literature Cited

1. Macbride and Martin, 1934. The Myxomycetes. Macmillan. New York.

2. Whetzel, H. H., 1902. Notes on the genus Stemonitis. Proc. Ind. Acad. Sci. **1901**:261-266.

3. Seifriz and Zetzmann, 1935. A slime-mould pigment as indicator of acidity. Protoplasma **23**:175-179.

4. Macbride, Thomas H., 1932. The North American slime-moulds. Macmillan. New York.

ADDITIONS TO THE VASCULAR FLORA OF JASPER COUNTY, INDIANA. II.[1]

WINONA H. WELCH, DePauw University

All specimens upon which the following enumeration is based have been collected by the author and deposited, with data, in the Herbarium of DePauw University.

In May, 1934, the genera Carex and Scirpus in the DePauw Herbarium were lent, for critical study, to Prof. Frederick J. Hermann, University of Michigan Botanic Gardens and Arboretum, and Sister Mary St. Leona Thornton, Mundelein College, Chicago, respectively.

Upon the basis of the determinations made by Prof. Hermann, the species of Carex collected in Jasper County, Indiana, by the author are: *_Carex annectens_ Bicknell, *_C. blanda_ Dewey, *_C. brevior_ (Dewey) Mack., *_C. Buxbaumii_ Wahl., _C. cephalophora_ Muhl., *_C. convoluta_ Mack., _C. cristatella_ Britton, *_C. Haydeni_ Dewey, _C. hystricina_ Muhl., _C. lanuginosa_ Michx., *_C. Longii_ Mack., _C. lupulina_ Muhl., _C. normalis_ Mack., _C. scoparia_ Schkuhr., *_C. suberecta_ (Olney) Britton, _C. Swanii_ (Fernald) Mack., _C. tribuloides_ Wahl., _C. vesicaria_ L., _C. virescens_ Muhl., and _C. vulpinoidea_ Michx.

According to the determinations of Sister Mary St. Leona Thornton the following are the species of Scirpus which the author has collected in Jasper County. _Scirpus atrovirens_ Muhl., _S. cyperinus_ (L.) Kunth., _S. lineatus_ Michx., *_S. occidentalis_ (S. Wats.) Chase, and _S. Smithii_ Gray, var. _setosus_ Fernald.

The following plants have not been reported heretofore from Jasper County by the author:

Primulaceae: _Samolus floribundus_ HBK.

Compositae: _Bidens vulgata_ Greene, var. _puberula_ (Wiegand) Greene, _Gnaphalium purpureum_ L., and _Tragopogon pratensis_ L.

---

[1] For previous papers of this series, see Proc. Ind. Acad. Sci. **36**:214. 1927; **40**:119. 1931.

*Not previously reported in Jasper County by the author.

BOREAL PLANT RELICS IN INDIANA

WINONA H. WELCH, DePauw University

"It is not known positively that either of the first two recognized ice advances of the Pleistocene period came into the Indiana region. Both the Nebraskan and Kansas ice sheets locally advanced much further south than the latitude of northern Indiana, and it is quite likely that one or both of these earlier ice sheets advanced far enough south to enter the Indiana region".[1] The boundaries of the Illinois and Wisconsin glaciers have been carefully located[1] by geologists of the state (Fig. 1).

On the basis of glaciation, Indiana is divided into two divisions: the glaciated and the unglaciated (Fig. 1). The glaciated area is largely a plain of glacial construction and the unglaciated portion shows the results of long subjection to weathering agencies and running water. Approximately 30,100 square miles (five-sixths of the state) were glaciated and about 6,250 square miles (a sixth) were untouched by the ice. There are two distinct divisions of the glaciated portion (Fig. 1). The northern fourth of the state, known as the Northern Moraine and Lake Region, is characterized by numerous moraine lakes and by lacustrine plains. The remainder of the glaciated area, approximately 11,900 square miles (nearly a third of the area of the entire state), is recognized as the Tipton till plain, which is chiefly characterized by a covering of glacial till of nearly level surface without lakes and not well dissected by streams. This till plain is subdivided into two sections, the Illinoian, which is the older and more southern, and the Wisconsin, the younger and more northern. Although there are no lakes in the Tipton till plain, marshes and swamps were formerly common but have since been drained artificially. This plain is the highly productive area of the state.

Thus, in a general way, the physiography of Indiana and the possible habitats of the plants are presented. There are at least four factors which have greatly changed these natural habitats, and, which, as a result, have influenced more or less the flora of the area. These factors are acidity and alkalinity of soil, drainage, agriculture, and grazing. The acidity and alkalinity of the soil are probably two major factors in bringing about the discontinuous distribution of some boreal relics in Indiana. Plants which have a wide range of pH tolerance are found throughout the state, and those which require acid or alkaline habitats are restricted to these respective areas. Thus, it is logical to assume that at the close of the glacial period many plants may have been left in unfavorable habitats with regard to ecological factors and failed to survive, leaving a few scattered, more fortunate members of the species to survive as relics of the ice age and to continue the species through the thousands of succeeding years. Doubtlessly the drainage of many bogs and swamps has ruined the habitats of other relic species, causing a decrease in the number of plants of the surviving species if not the extinction of the species in our area. The cultivation of large areas of the state for the various crops probably has caused a reduction in numbers and in frequency of many of the relic species. It seems that this explanation would be applicable especially to the Tipton till plain. The results of grazing are evident without discussion.

---

[1] Malott, C. A. 1922. The physiography of Indiana. Handbook of Indiana geology, pp. 141-152.

There are approximately 300 species[2] of plants of a northern range within the longitude of Indiana that reach the southern limit of their distribution in Indiana. Boreal plants in North America are those which have a mass distribution in the northern portion of the continent at the present time. Boreal relics in Indiana are considered to be boreal plants which have a discontinuous distribution in our area and occur in increasing numbers northward. This paper deals with plants, within the longitude of Indiana,[3] whose mass distribution is north of Indiana and whose southern limit within this longitude is not south of the glaciated area, except in a portion which has the possibility of having been directly influenced by the glacier. Those plants which do grow in continuous similar habitats are said to have discontinuous or interrupted distribution. Specimens of relic species are usually few in number in each locality of occurrence. Some of the boreal species which gradually migrated southward during the Pleistocene times found favorable spots in Indiana. Here they have remained since the retreat of the glaciers and have survived the competition of other plants. These surviving plants are peculiar to certain restricted habitats. There are at least three possible explanations of the presence of boreal relic plants in Indiana. Firstly, the plants were brought southward by the glacier. Those in the most favorable habitats survived when the ice melted. Thus northern species were introduced into Indiana. The advancement of the boreal plants from the north in front of the ice and the gradual return, by survival in favorable situations and death in unfavorable locations, of the boreal species from the south toward the north, with the increase in temperature upon the retreat of the glacier, is considered by the author as vertical migration of the boreal plants. Secondly, boreal plants might have survived the ice period in the Appalachian region and migrated westward into Indiana since the ice age. Or, thirdly, the species might have been boreal relics in states west or northwest of Indiana and migrated eastward into the state since the retreat of the glacier. The last two methods illustrate a type of introduction of boreal species which may be regarded as lateral or horizontal post-glacial migration.

The county distribution and the habitats of these boreal relics in Indiana are based largely upon the data obtained from the specimens in the Deam Herbarium, Bluffton, Indiana. The accompanying maps show the distribution of each species in relation to the physiographic divisions of the state.[4] For ready reference the species and genera have been arranged alphabetically in the enumeration and in the illustrations. The list includes twenty-two species.

---

[2] Deam, C. C. 1925. Flora of Indiana: on the distribution of the ferns, fern allies and flowering plants. Proc. Ind. Acad. Sci. 34:39-53.

[3] Longitude 86° and latitude 40° cross near the geographic center of the state.

[4] The distribution of many of these species in counties of neighboring states aids in determining the boreal relic plants in Indiana. See: Schaffner, John H., 1914. Catalog of Ohio vascular plants. Ohio Biol. Surv. Bull. 2, 1:127-247; Transeau, E. N. & Williams, P. E., 1929. Distribution maps of certain plants in Ohio. Ohio Biol. Surv. Bull. 20, 4:181-217.

Indiana boreal relic plants and their distribution by counties

Carex eburnea Boott. Dry sandy or rocky soil, preferring limestone. E. Que. and N. B. to Mackenzie and Alb., s. locally to Va., Ohio, Ky., Ind., Mo., and Neb. Indiana Dist.—Lake, Jefferson counties.

Carex projecta Mack. Damp soil. Gulf of St. Lawrence and N. S. to Ont. and N. Dak., s. to N. Y., Conn., D. C., Ind., Ill., and Ia. Ind. Dist.—Hendricks, Marion.

Circaea alpina L. Bogs and moist woods. Lab. to Alaska, s. to Ga., Ohio, Ind., Mich., n. e. Ia., and S. Dak. Ind. Dist.—Porter, Laporte, Lagrange, Steuben, Allen, Montgomery.

Cornus rugosa Lam. Wooded bluffs, sandy, rocky situations. E. Que. and N. S. to Man., s. to Va., Ohio, Ind., Ill., Ia., and N. Dak. Ind. Dist.—Lake, Porter, Laporte, St. Joseph, Lagrange, Montgomery.

Cypripedium reginae Ait. Swamps, bogs, woods. Nfd. to Ont., Ga., Ind., Wis., Minn., and Mo. Ind. Dist.—Lake, Laporte, Lagrange, Steuben, Cass, Tippecanoe, Montgomery, Henry.

Diervilla Lonicera Mill. Dry or rocky wooded ridges or slopes. Nfd. to Man., s. to N. C., Ohio, Ind., and Wis. Ind. Dist.—Lake, Porter, Laporte, Starke, Jasper, Fountain.

Eleocharis intermedia (Muhl.) Schultes. Marshes, springy boggy places. Que. to Ont., s. w. to N. J., Pa., Ohio., Ind., Ill., and Ia. Ind. Dist.—Laporte, Noble, Marshall, Starke, Steuben, Whitley, Knox.

Gentiana procera Holm. Wet places. Ont. to Man., s. to N. Y., Ind., Ia., Minn., and S. Dak. Ind. Dist.—Lagrange, St. Joseph, Steuben, Fulton, Madison, Tippecanoe.

Habenaria orbiculata (Pursh) Torr. Rich woods. Lab. and Nfd. to Alaska and B. C., s. to N. C., Ohio, Ind., Minn., and Wash. Ind. Dist.—Marshall, Wells.

Hydrocotyle americana L. Wet places. N. S. to Ont. and Minn., s. to southern N. Y., Pa., and in the mts. to N. C. Ind. Dist.—Lagrange, Jefferson.

Juniperus communis L., var. *depressa* Pursh. Sand dunes, weathered rocky slopes. Nfd. to southern New England and the shores of the Great Lakes. Ind. Dist.—Lake, Porter, Laporte, Elkhart, Steuben, Wayne, Jefferson.

Maianthemum canadense Desf. Moist woods. Lab. and Nfd. to Mackenzie and Man., s. to N. C., Tenn., Ohio, Ind., Ia., and S. Dak. Ind. Dist.—Laporte, St. Joseph, Elkhart, Steuben, DeKalb, Noble, Kosciusko, Marshall, Jefferson. Although Jefferson County is in the glaciated area, it is possible that this species is not a boreal relic but has entered this particular locality from Ohio where it is reported as having a general distribution.[5]

Panax trifolium L. In moist woods and thickets. N. S. to W. Ont., s. to Del., Md., Ill., Ia., and along the mts. to Ga. Ind. Dist.—Lake, Porter, St. Joseph, Elkhart, Steuben, DeKalb, Noble, Kosciusko, Marshall, Carroll, Decatur, Jennings.

---

[5] Schaffner, John H. 1914. Catalog of Ohio vascular plants. Ohio Biol. Surv. Bull. 2, 1:127-247.

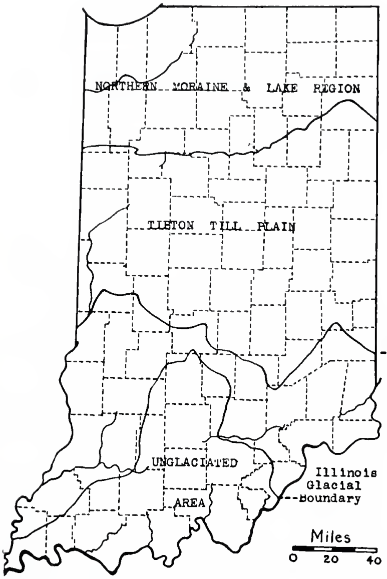

NORTHERN MORAINE & LAKE REGION
TIPTON TILL PLAIN
Wisconsin Glacial Boundary
UNGLACIATED AREA
Illinois Glacial Boundary
Miles
0 20 40

Fig. 1. Regional units of Indiana based on glaciation

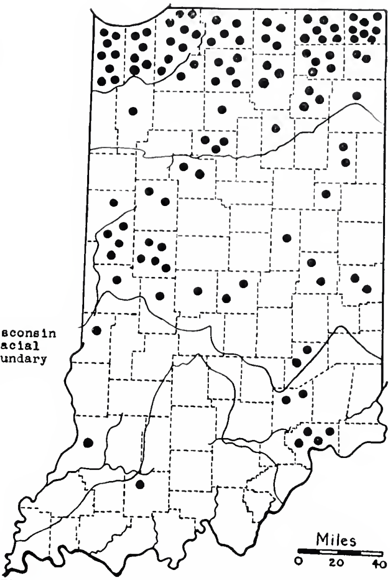
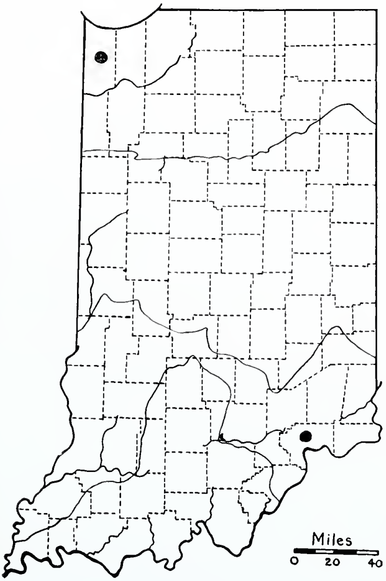
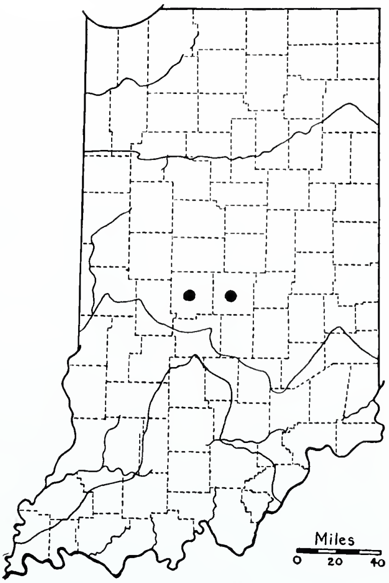


Fig. 2. Distribution of boreal relic species in Indiana according to counties.



Carex eburnea



Carex projecta

Figs. 1-4.

Pinus Strobus L. Sand dunes, marshy places, sandstone outcrops. Nfd. to Man., s. along the mts. to Ga., w. to Ind., Ill., and e. Ia. Ind. Dist.—Lake, Porter, Laporte, St. Joseph, Warren, Fountain, Montgomery.

Poa paludigena Fernald and Wiegand. Wet places. N. Y., Pa., Mich., Ill., Ind. Ind. Dist.—Lagrange, Dubois. Although only the northwestern portion of Dubois county was glaciated, there was, according to geologists, a lake extending several miles beyond the ice. Probably this species illustrates the persistence of a plant beyond the glacier. (It was collected in Dillon Swamp, about 4 miles north of Jasper.)

Potentilla fruticosa L. In swamps or moist rocky places. Greenland and Lab. to Alaska, s. to N. J., Pa., Ohio, Ind., Ill., n. Ia., Minn., in the Rocky Mts. to Ariz., and in the Sierra Nevada to Cal. Ind. Dist.—Lake, Laporte, Lagrange, Steuben, Noble, Kosciusko, Marshall, Whitley, Wabash, Cass, Henry, Wayne, Decatur.

Prunus nigra Ait. Low woods. N. B. to Assin., s. to N. Y., Ohio, Ind., Wis. Ind. Dist.—Elkhart, Wells, Blackford, Marion.

Sanguisorba canadensis L. Swamps and low meadows. Lab. and Nfd., s. to mts. of Ga. and w. to Ohio, Ind., and Mich., and on west coast, B. C. to Alaska. Ind. Dist.—Fountain, Vigo.

Schizachne purpurascens (Torr.) Swallen. Rocky wooded slopes. Lab. to Alaska, s. to Pa., Ind., S. Dak., and in mts. to N. Mex. Ind. Dist.—Cass.

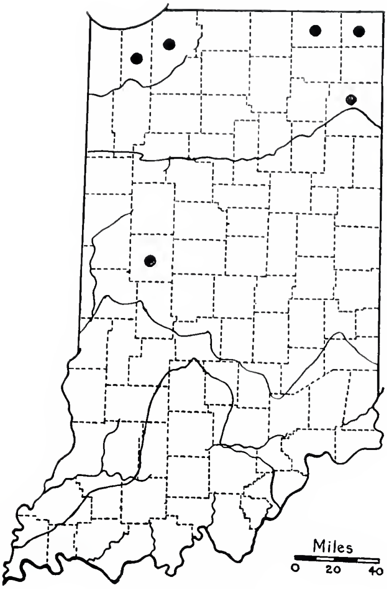
Spiranthes lucida (H. H. Eaton) Ames. Moist banks and woods. N. S. to Ont. and Minn., s. to Va., Pa., Ohio, Ind., and Wis. Ind. Dist.—Noble, Whitley, Carroll, Jennings.

Taxus canadensis Marsh. Woods, near upper edge of canyons. Nfd. to Man., s. to N. J., in Alleghenies to Va., Ohio, Ind., Ia., and Minn. Ind. Dist.—Montgomery, Parke, Putnam.

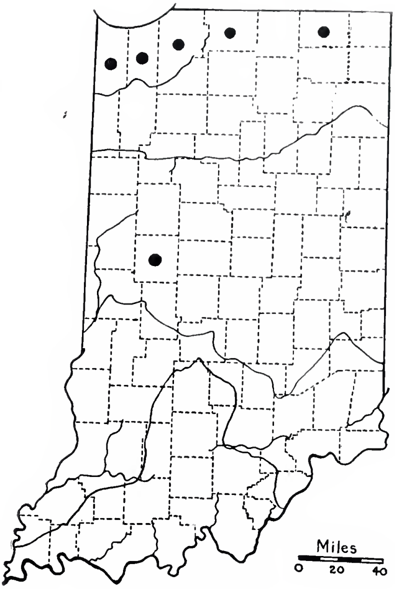
Vaccinium canadense Kalm. Rocky wooded slopes. Lab. to Man., s. in mts. to Va., Pa., Ohio, Ind., Ill., and Mich. Ind. Dist.—Fountain.

As is shown in Fig. 2, there is a gradual reduction in the number of boreal relic species from the northern portion of the state to the southern; the number of boreal relic species in the Wisconsin portion of the Tipton till plain is approximately three times that in the Illinoian; and the number of boreal relic species in Montgomery county is larger than in any other county in the Tipton till plain, with Fountain County ranking second in this respect.

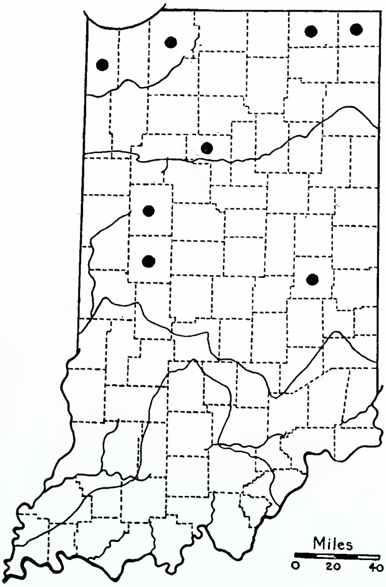
Because of the lack of definite information concerning the distribution in Michigan of the boreal species occurring in the Northern Moraine and Lake Region of Indiana, it is impossible to decide whether or not these species are relics. The names of several of these boreal plants follow, although no attempt has been made to exhaust the list: *Andromeda glaucophylla*, *Calla palustris*, *Carex Bebbii*, *Chamaedaphne calyculata*, *Clintonia borealis*, *Coptis trifolia*, *Corydalis sempervirens*, *Eleocharis pauciflora*, *Eriophorum callitrix*, *Habenaria hyperborea*, *Larix laricina*, *Linnaea borealis*, *Myosotis laxa*, *Myrica asplenifolia*, *Nemopanthus mucronata*, *Pinus Banksiana*, *Polygala pauciflora*, *Thuja occidentalis*, and *Trientalis americana*.



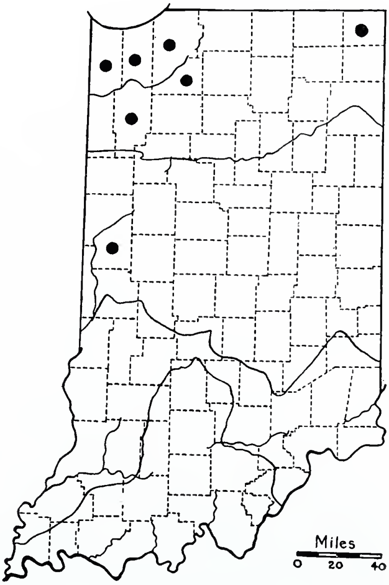
Circaea alpina



Cornus rugosa

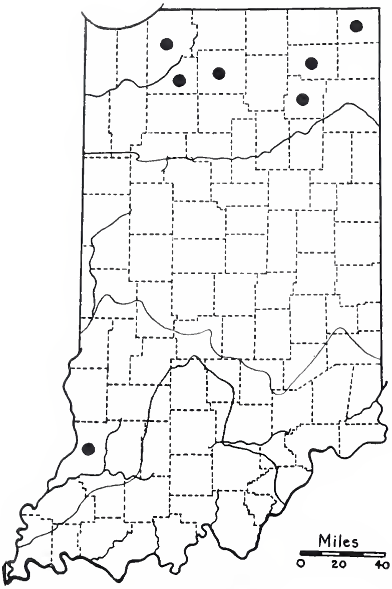


Cypripedium reginae

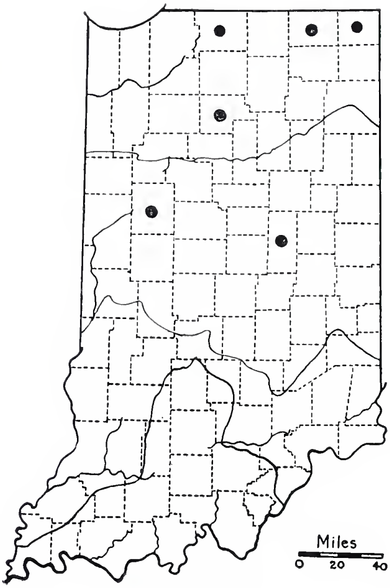


Diervilla Lonicera

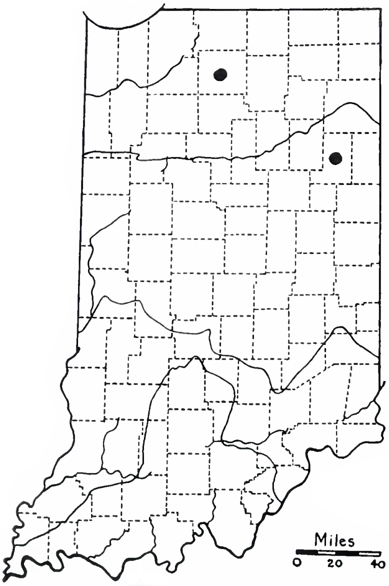
Figs. 5-8.



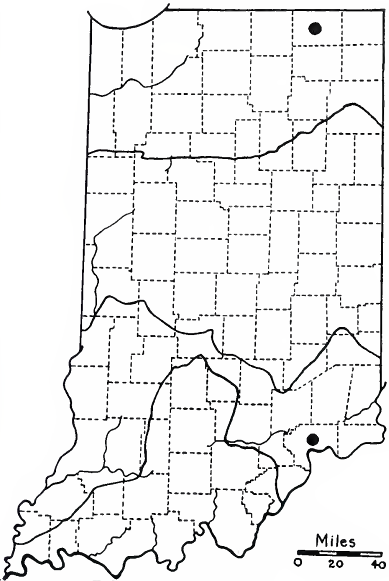
Eleocharis intermedia



Gentiana procera

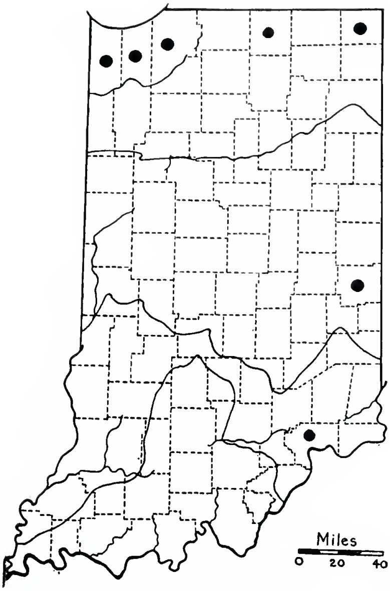


Habenaria orbiculata

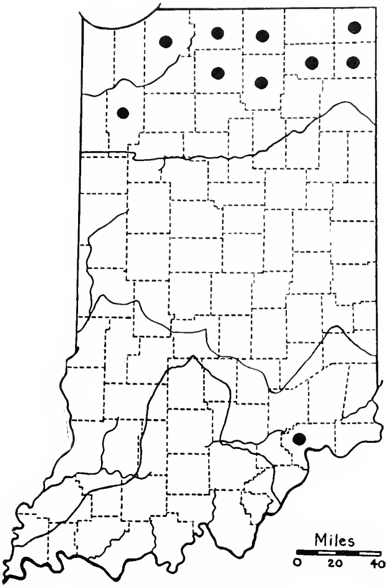


Hydrocotyle americana

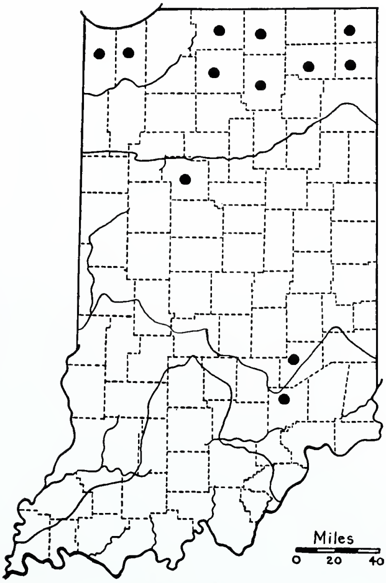
Figs. 9-12.



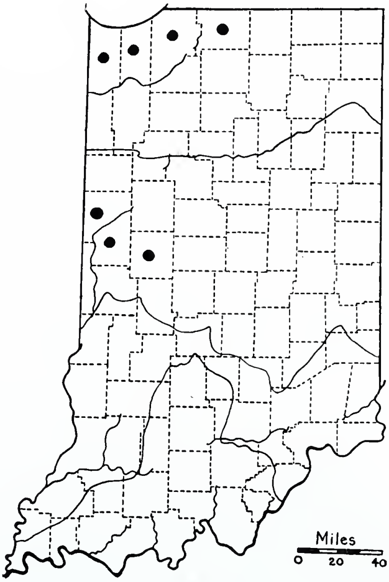
Juniperus communis depressa



Maianthemum canadense

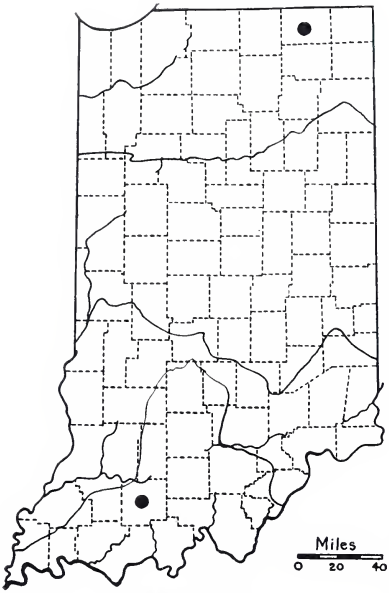


Panax trifolium

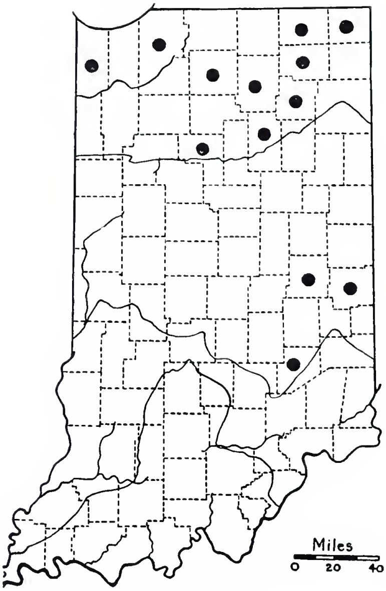


Pinus Strobus

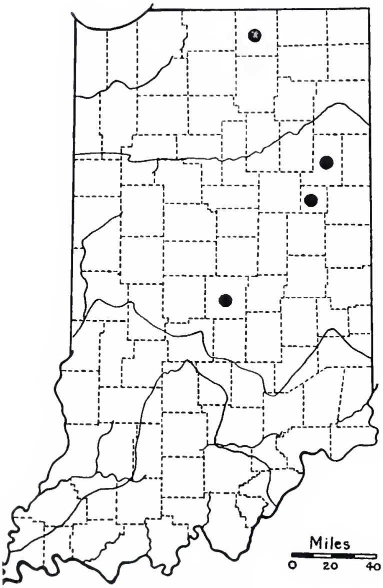
Figs. 13-16.



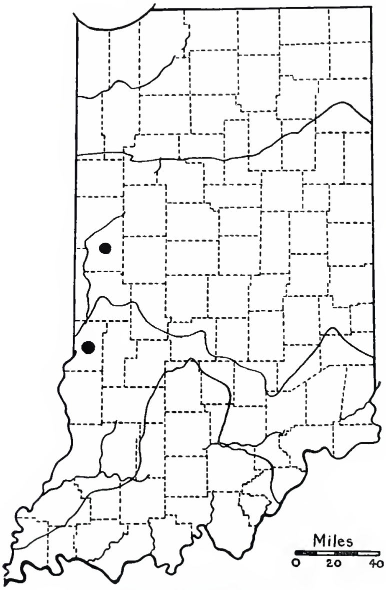
Poa paludigena



Potentilla fruticosa

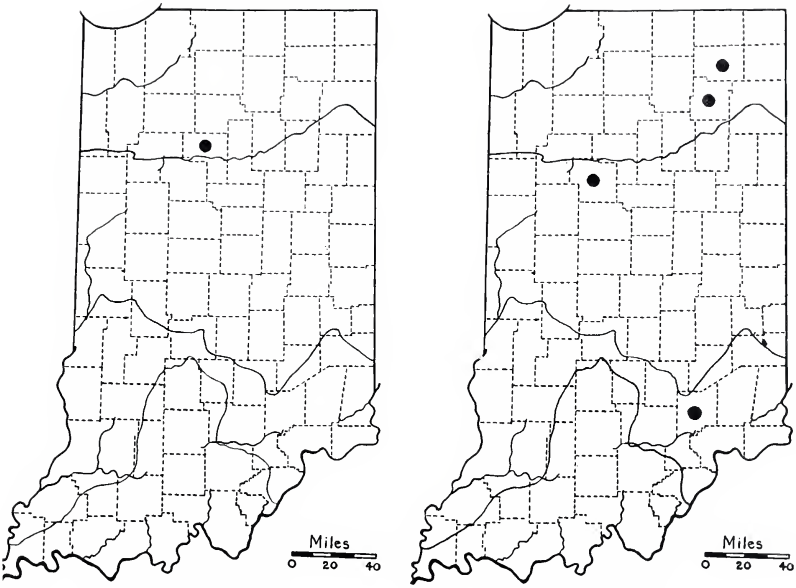


Prunus nigra



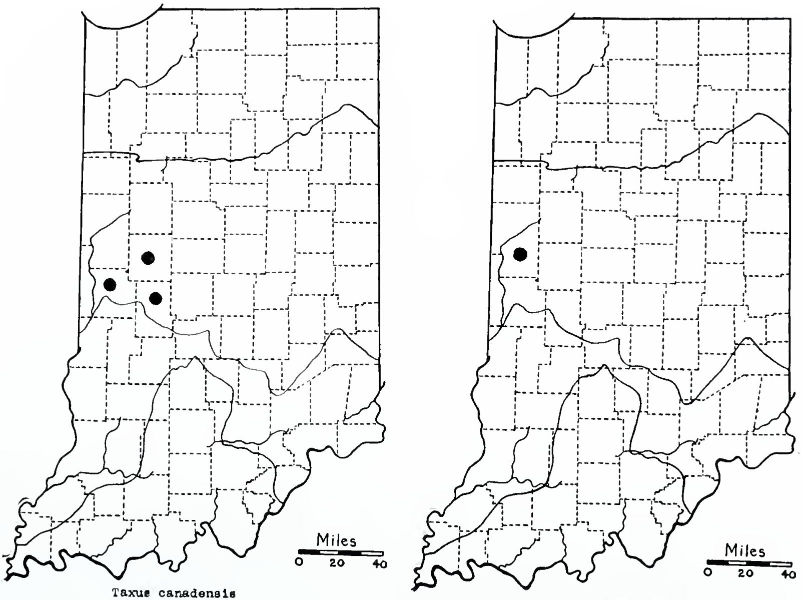
Sanguisorba canadensis

Figs. 17-20.



Schizachne purpurascens

Spiranthes lucida



Taxus canadensis

Vaccinium canadense

Figs. 21-24.

Several species of plants that are members of the flora of the Allegheny plateau and the Appalachian mountains are found in Indiana. Although the list may be incomplete, the following species are noteworthy: *Castanea dentata*, *Hydrangea arborescens*, *Kalmia latifolia*, *Pinus virginiana*, *Rubus odoratus*, *Quercus Prinus*, and *Tsuga canadensis*.

Because *Betula lutea* is found in several counties in the Northern Moraine and Lake Region it seems that it belongs with the group of boreal plants which may or may not be relic species. Since it is difficult to understand how the presence of this species in Crawford County can be due to the glacier, perhaps it is more satisfactory to classify the yellow birch in southern Indiana with the plants that have their origin in the flora of the eastern mountains.

The very helpful suggestions of Dr. C. C. Deam and Prof. H. C. Cowles and the use of the Deam Herbarium in the preparation of this paper are greatly appreciated.

NOTES ON PLANTS OF JEFFERSON COUNTY NEW OR RARE IN INDIANA

Edna Banta, Indiana University

At one time considerable work was done on the flora of Jefferson County, Indiana, and three lists were published, A. H. Young's in 1871, J. M. Coulter's in 1874, and C. R. Barnes' in 1877. Since these lists are not completely substantiated by herbarium specimens, and because there have been many changes in habitat factors due to the clearing and cultivating of the land, it seemed worth while to make another study of this flora. Hence in the spring of 1933, I began a collection of the vascular plants of the county, and, although more than one thousand species and varieties have been collected, the list is not yet nearly complete. A full report of this study will be published later; meanwhile it seemed advisable to report certain new or unusual plants.

Specimens of the species here reported are in my herbarium, which is later to be deposited in the herbarium of Indiana University. Duplicate specimens have been sent to Chas. C. Deam and are in the Deam Herbarium. All identifications have been verified by Mr. Deam or by specialists to whom he has referred them. The nomenclature is that in use at the Gray Herbarium. If a new name has been adopted, the name used in Gray's Manual (7th edition) follows it in brackets.

The following species are new to the state:

1. *Dentaria multifida* Muhl. Harbarts Creek, April 4, 1934.

A small colony of this was found at the base of a slope near where Harbarts Creek flows into Big Creek, about one mile south of Volga. All efforts to identify it having failed, specimens were collected in April, 1935, and sent to the Gray Herbarium for identification. The report received was: "*Dentaria multifida* Muhl. a good find." It is described and given species rank in the 1933 edition of Small's Flora of the Southeastern States and in the 6th. edition of Gray's Manual, but it is entirely ignored in the 7th. edition of Gray's Manual and in the 2nd. edition of Britton and Brown's Illustrated Flora. Range, according to Small: Appalachian provinces, Ga., Ala., and Ohio.

2. *Rubus phoenicolasius* Maxim. Crow Ravine, June 3, 1935.

This Asiatic species was sold and introduced into gardens in Hanover under the name of Japanese wine berry. It was cultivated for a few years but proved so dissappointing that it was subsequently dug up and thrown on dump heaps. I first noticed it as an escape in 1924, when I found a few plants of it in Crow Ravine some distance below Crow Falls. Above Crow Falls there is at present a thrifty colony of it, which seems to be a survival of a former dump.

3. *Geranium columbinum* L. Harbarts Creek, May 22, 1934.

One plant of this European species was found in a pasture one mile southwest of Wirt. In 1935 it was found as a common weed in a strawberry patch about one mile west of the first station and in a fallow field about one mile east of the first station. Range, according to Gray's Manual: Borders of fields, etc., N. J. and Pa. to Va., also Dak.

4. *Hypericum aureum* Bartr. Clifty Falls Park, July 10, 1935.

This southern shrub was discovered by Mr. Merritt Carr, custodian of Clifty Falls State Park. It is growing in a thicket on the steep rocky slope of the hill southeast of the reservoir for Clifty Inn. Careful investigation uncovered no evidence of its ever having been planted there or near by. If it is an escape, its source is not known. Range, according to Britton Brown: River banks and bluffs, S. C. to Tenn., Ky., and Tex.

5. *Bupleurum rotundifolium* L. Lost Fork, June 6, 1934.

The only station for this plant is along a creek bank three miles east of Brooksburg. It was noted in 1926 by A. L. Banta, who found it while mowing weeds along the creek. It still persists here after eight years. Since it grows among weeds which are taller and more conspicuous, it is not easily found, and other stations may thus be overlooked. Range, according to Gray's Manual: N. H. to N. C., S. Dak., and Ariz.

6. *Torilis anthriscus* (L.) Bernh. Brooksburg Road, May 20, 1934.

This introduced umbellifer is a common and conspicuous weed on the south slopes of the hills east of Madison and extending eastward to state road 129. General range, according to Gray's Manual: N. Y. to D. C., Ky., and Ohio.

7. *Rudbeckia bicolor* Nutt. Big Creek, August 8, 1935.

This unusual looking Rudbeckia was collected on the farm of William Boyd, one mile east of Lancaster. It was growing in a stubble field, at the crest of high bluffs along Big Creek. In size and vegetative characters it is similar to *Rudbeckia hirta* L., but the flowers are conspicuously different in having brownish purple, trident-shaped spots at the base of the ligules of the ray flowers. It is a southern species said to grow on "dry hills and sandy soil, various provinces, Alabama to Texas, Arkansas and Tennessee."

8. *Crepis pulchra* L. Brooksburg road, May 20, 1934.

This introduced weed is common along state road 56 from Madison to Brooksburg a distance of eight miles. It is also found less commonly in fields and waste places three miles east of Brooksburg. It grows to a height of 2 to 4 feet and seems to be competing quite successfully with such weeds as *Lactuca canadensis* L. All the evidence seems to point to a noxious and successful weed. Little has been learned concerning its distribution. Gray's Manual states that it is locally established in Virginia. Specimens have been sent to the Gray Herbarium and to E. B. Babcock, who is studying the genus from the genetic standpoint.

The following plants are rare or extend the range of the species in the state:

9. *Pteretis nodulosa* (Michx.) Nieuwl. [*Onoclea Struthiopteris* (L.) Hoffm.] Chambers' Woods, August 8, 1934.

Only one colony of this fern was found. It is in a large primitive woods, known locally as the Chambers' Woods, about five miles north of North Madison along the Paper Mill Road. It was reported from Henry County by Joe R. Craw in 1932 and from Lawrence County by Ralph M. Kriebel in 1934. These are to date the most southern records in Indiana for this species. General distribution, according to Gray's Manual: Alluvial soil, Nfd. to Va., and north westward.

10. *Juniperus communis* var. *depressa* Pursh. Harbarts Creek, May 21, 1934.

This species is represented in the Jefferson County flora at present by two plants, growing along Harbarts Creek about two and three miles southwest of Wirt. The land owner told of three others that had been cut down in the last five or six years. The first of the two specimens is young and vigorous, 10.5 feet high and about 11 feet in spread. It consists of a whorl of stems decumbent for a few inches then soon erect, the whole plant having from a distance the appearance of a low branching specimen of *Juniperus virginiana* L. The second plant is old and much less vigorous and has many dead branches. It is about 12.5 feet high with a spread 15 feet. The first one is growing on a rather steep slope underlaid by Niagara Limestone. The most common tree growing with it is *Juniperus virginia* L. The second plant is at the crest of a very gentle slope which flattens out into a very flat, wet woods in which the most common tree is *Liquidambar Styraciflua* L.

The two stations are only a mile apart, but the first is steep and dry and faces east, while the second is moist and almost level and faces west. The distribution of this species in the state is scattered and its habitat varied. It is most common in the dunes along Lake Michigan, where it grows in pure sand. Deam reports it from the following interesting habitats: a hard clay woods in Elkhart County, muck ground in Laporte County, and a decadent tamarack swamp in Steuben County.

11. *Cyperus pseudovegetus* Steud. Near Chelsea, Aug. 2, 1935.

This species was found along a roadside ditch near Chelsea in the southwestern part of the county. It was common here for about a quarter of a mile. This habitat is typical of the southern Indiana flats. The one published record for the state is for Posey County, by Deam. Distribution: Del. to Fla., west to Kan. and Tex.

12. *Eleocharis quadrangulata* (Michx.) R. and G. North Madison, August 8, 1934.

This species is abundant in the railroad pond at North Madison, and about one mile north of Madison it is again found in a pond on a farm belonging to Joseph M. Cravens. In the lake area it is common, but south of there it has been reported only for Crawford and Harrison counties.

13. *Rynchospora capitellata* (Michx.) Vahl. [*R. glomerata* (L.) Vahl] Near Chelsea, August 28, 1935.

This species is common in a flat, very wet clearing in a woods about a mile northeast of Chelsea and six miles southwest of Hanover. It is common in the lake area of the state but south of there it has not been reported.

14. *Spiranthes Beckii* Lindl. Harbarts Creek, August 28, 1934.

This specimen was found on a dry clay bank in a pine woods along Harbarts Creek two miles southwest of Wirt. It has been reported by

Deam from an open black oak woods in Harrison County and from an open white oak woods in Owen County. It is easily overlooked and is probably not as rare as it seems. General distribution, according to Gray's Manual: Dry soil near the coast, Mass. to Fla. and Tex., inland in the Miss. Valley to Ky. and Ark.

15. *Ranunculus pusillus* Nutt. Near Volga, June 3, 1933.

I have this species from two stations in the county, which are about ten miles apart. The first station was a low flat, very wet woods, about one mile south of Volga. The second was a similar woods about one-half mile northeast of Chelsea and six miles southwest of Hanover. It has been reported from Posey and Harison counties by Deam, and from Knox County in Coulter's Catalogue for Spillman. Distribution, according to Gray's Manual: Wet places near the coast, southern N. Y. to Fla. and Tex., north in the Miss. basin to Mo. and Tenn.

16. *Thlaspi perfoliatum* L. Brooksburg Road, April 5, 1933.

I have a specimen of this in a plant collection made while a student in Hanover College in 1924. A marginal note in the Gray's Manual of Dr. A. H. Young of Hanover, shows that this specimen was the first to come to his attention. At that time only a small colony of it was found; now it is common along state road 56 east of Madison and along the Wolf Run Road northwest of Manville. The only published record for Indiana is for St. Joseph County.

17. *Rosa micrantha* Borer. East of Madison, June 1, 1934.

This rose has taken possession of a steep rocky pasture about one-half mile east of the Madison City limits. From here it extends north along the slopes of Goat Hollow for perhaps one-half mile, and occasional specimens are found for five or six miles east along state road 56. It is a native of Europe and has been reported as an escape in Clark County by Baird and Taylor, and from Jefferson County by Barnes and by Young. Since the extent to which it had escaped was not noted in those reports I am including it in this list.

18. *Prunus Mahaleb* L. Clifty Falls Park, June 14, 1934.

This southern European species has been reported previously for Jefferson County and is included here merely to note its abundance. It is now quite common in woods and thickets on the hillsides around Madison. It seems to grow best on dry, warm slopes and is reproducing freely. It begins to flower and fruit when small, many fruiting specimens being only small shrub size. Birds are probably the distributing agent, for the fruits are much relished by them.

19. *Oxalis florida* Salisb. [*O. filipes* Small.] Harbarts Creek, June 2, 1935.

Specimens of this were collected in a low woods two miles southwest of Wirt. The only other report for this species in Indiana is from Perry County by Deam.

20. *Orobanche Ludoviciana* Nutt. Brooksburg, Sept. 15, 1935.

This parasite was found by a tobacco grower near Brooksburg and given to me to identify. I visited the field and found it growing on the tobacco roots, but the manuals state that it is parasitic on the roots of *Ambrosia trifida* L. An inquiry concerning its host plants was sent to the U. S. Department of Agriculture. The following information was received in a letter from H. A. Allard: "It appears that this species has been reported upon *Artemesia frigida* W., *Artemesia tridenta* Nutt., and also upon *Psoralea verrucosa* L. It does not appear to have been reported upon tobacco. The species sometimes affecting tobacco in the Kentucky area is *Orobancche ramosa* L." My specimen cannot be *O. ramosa* L., for it has a distinctly five cleft calyx, and *O. ramosa* is described as having a four lobed calyx. This character is a key character in separating these two species.

21. *Hydrocotyle americana* L. Bluffs, Big Creek, August 11, 1935.

A small colony of this species was found along Big Creek about one mile south of Lancaster. It was growing high upon the north face of a cliff, kept moist by the drip from a spring. At the crest of the cliff the conspicuous members of the tree flora were *Tsuga canadensis* (L.) Carriere and *Castanea dentata* (Marshall) Borkh. Deam reports this from a cranberry bog in Lagrange County. These two habitats, a cranberry bog in the extreme northern part of the state and a limestone cliff in the extreme southern part of the state, afford a most striking contrast. The Lagrange County report is the only other report for the state.

22. *Martynia louisianica* Mill.[1] Harbarts Creek, June 24, 1934.

This was found growing as a weed in a garden two miles southwest of Wirt. The owner of the garden told me that it had been a weed about the premises for each of the ten years that he had owned the land. This is the only place where it is now known to occur in the county, although it was reported by Barnes in 1877 as common along the Ohio River at Madison.

23. *Carduus nutans* L. Lost Fork, June 12, 1934.

This European migrant was found in a pasture along the Lost Fork Road three miles east of Brooksburg. The owner of the land told me that it appeared there first when the field was planted to alfalfa about six years ago. It is now well established and becoming a pest. The only other report for the state is for Elkhart County, by Albert Hansen in 1924.

---

[1] The correct spelling is *louisianica* Mill. not *louisiana* Mill. It seems that the latter was a misprint of some sort and was corrected in the errata at the end of the 8th. edition of Miller's Garden Dictionary. See also: Howell, 1933. Martynia louisianica Mill., a correction. Leafl. Western Bot. 1:80.

A PRELIMINARY STUDY OF SOIL PASTEURIZATION

R. B. ZUMSTEIN, Purdue University

There are many micro-organisms living in the soil, some of which are of parasitic nature and capable of producing serious plant diseases. Various methods of treating the soil to destroy these disease-producing organisms are recognized as important means of plant disease control. Some of the methods, at least, are commonly referred to as soil *sterilization*. This term is misleading, however, since it implies the destruction of all micro-organisms in the soil, some of which may be distinctly beneficial ones. Either of two terms might be used instead of the term sterilization. The term *disinfect* may be used to describe methods that free the soil of the disease-producing organisms, since these organisms do "infest" the soil but do not "infect" it. The term *pasteurization* may also be used to describe methods that destroy or inactivate or attenuate certain organisms, thus destroying their disease-producing capacity, without similarly affecting other components of the soil microflora.

In this paper we shall use the term *pasteurization* to imply destruction or inactivation of the disease-producing organisms. Pasteurization has proved quite satisfactory in greenhouses, seed beds, etc., where various methods are used extensively.

The soil may be pasteurized in various ways. The application of heat, either dry or in the form of steam, is advocated by some as being efficient and inexpensive, in spite of the fact that considerable equipment must be installed and maintained. A newer method of applying heat to the soil is by electrical means, using either a heating cable or copper electrodes placed in shallow soil 2 to 4 inches apart.

The use of various chemicals, such as the mercury salts, formaldehyde, acetic acid, caustic lime, copper sulphate, zinc chloride, sulphuric acid, calcium cyanamide, and others, has been recommended as very efficient in pasteurizing the soil, the fungicides varying considerably in concentration and method of application, depending on the type of soil, moisture content, and the organisms in the soil.

All of these methods have been used experimentally and some are being used commercially in the larger greenhouses and forest nurseries, where it is less expensive to pasteurize the soil than to furnish a new supply. There has been considerable thought that the temperatures used in pasteurization have been too high and that many of the beneficial organisms have been destroyed unnecessarily. Little work has been done on the determination of the thermal death point of the pathogenic soil fungi in order to know more definitely the temperature to which the soil should be subjected either to destroy these organisms or else inactivate them so that they will be unable to harm crop plants. It may be that the most objectionable organisms may be inactivated at such a low temperature as not to disturb other soil relationships. This study was undertaken to determine the thermal death point of some of the more important fungi causing "damping-off" of seedlings. It is concerned only with the thermal death point determinations *in vitro* in pure culture.

The following fungi commonly found in the soil were studied: *Sclerotium rolfsii, Fusarium lycopersici, Fusarium eumartii, Sclerotium* *delphinii, Pythium debaryanum, Macrosporium solani,* and *Botrytis cinerea.*

Review of Literature

The results obtained by investigators vary considerably, due to difference in methods used and also to variation in organisms studied. A summary of results, however, seems to indicate that a temperature of 100° C. is beyond the temperature necessary to inactivate the pathogenic fungi studied. Bewly and Budden **(1)**, in their study of the pathogenic organisms found in the water used for greenhouse purposes, claim that a temperature of from 50° to 70° for 1 minute is sufficient to kill the mycelium and summer spores of the fungi found in the water supply. In the study of greenhouse sterilization by Brown, Baldwin and Conner **(2)** the following soil fungi among others can be controlled by a temperature of 60° C.: Rhizoctonia on lettuce, and Pythium. The method is not given. Pathogenic organisms in the soil can be destroyed in 4-inch pots according to Byars and Gilbert **(3)** by submerging them for 5 minutes in water at 98° C. and in 8-inch pots by the application of 3,000 cc. of water heated to 98° C. This method varies considerably from some of the others in that these organisms are growing naturally in the soil.

In relation to *Sclerotium rolfsii*, Higgins **(4)** claims that its maximum temperature for growth is 40° C., but that 37° seems to be the maximum for continued normal growth. Jorgensen **(5)**, in testing soil disinfectants, says that heating soil containing *Pythium debaryanum* 2-3 hours, 90°-95° C., definitely controls this fungus. Using electricity as a source of heat in sterilizing soil, Newhall **(6)** claims that *Rhizoctonia solani, Pythium ultimi* and *Fusarium* sp. can be killed in varying lengths of time by raising the temperature to 71° C. or less. According to Newton **(8)**, however, the lethal temperature for *Rhizoctonia solani* is one hour at 50° C. for both mycelium and sclerotia. In order to get partial sterilization of soil for greenhouse work, Russell and Hutchinson **(9)** hold that the soil should be heated from 82°-94° C. in order to get the most satisfactory results, although Scheffer **(10)** claims that, in order to disinfect coniferous seed beds efficiently, they should be subjected to a temperature of 70° C. for a few minutes insuring this temperature to a minimum depth of 4 inches. Scott **(11)**, using electricity to pasteurize soil in greenhouse flats and benches, holds with Russell and Hutchinson when he recommends a temperature of 82° C. as sufficient for sterilization and claims that electricity is a less expensive source of energy. *Macrosporium solani,* according to Wallace and Tanner **(12)**, shows considerable variation in resistance to heat, depending on the solution in which it is placed while being heated. In salt solution it resisted 50° C. for 30 minutes, but was killed at 55° in 10 minutes. In a sugar solution the suspension was killed within 25 minutes at 50° C. and in 5-10 minutes at 55° C. In the case of *Sclerotium rolfsii (Corticium vagum)*, Watanabe **(13)** found that the sclerotia immersed in water were destroyed in 50 minutes at 50° C., and the mycelium in 30 minutes at 45° C., while in the air, a period of 60 minutes was necessary to kill sclerotia and 20 minutes for the mycelium.

Newhall and Nixon present evidence to show that a temperature above 70° C. in the presence of adequate soil moisture is not necessary to kill several soil pathogenes.

Method

Several preliminary trials were made with a number of these soil fungi using variations in method until the following technique was standardized. One-half cubic centimeter of distilled water was put into each of a number of small thin glass test tubes (½x4 in.). The tubes were plugged and autoclaved at 15 lbs. for 20 minutes, then removed and allowed to cool. A circular piece of agar on which the fungus had been growing was placed in each tube aseptically. A pure culture of the fungus was made on potato dextrose agar, and pieces were cut out of it with a small sharpened cork-borer. The tubes containing the fungus were then placed through holes bored in a large cork and floated on the surface of a water-bath with a constant temparture regulator. The tubes projected down into the water to a depth of 4-5 in. A thermometer was inserted through a hole in the center of the cork so that the lower end was at the same level as the bottom of the tubes. Another thermometer was suspended in the water-bath, giving readings at a lower level. For higher temperatures paraffin oil was poured on the surface of the water forming a thin film, which reduced evaporation considerably.

The tubes and the cork were then allowed to float on the surface of the water, and the tubes were removed at five minute intervals up to 30 minutes. As each tube was removed it was taken to the inoculation booth and the contents poured on a petri plate containing solidified potato dextrose agar, and each plate was labeled. A series of six plates were so prepared for each temperature and then incubated at a temperature of 25° C. for 24-48 hours. Readings were then made to determine the highest temperature at which the various fungi were able to continue to grow. Identical sections of inoculated agar were plated in each case as controls at the same time as the test tubes were prepared. Only six tubes were prepared at one time, the maximum for a certain tempera-

TABLE I.

Pathogen	Period of Heating Minutes	Highest Survival Temperature Recorded Degrees C.	Period of Heating Minutes	Lowest Lethal Temperature Recorded Degrees C.
Sclerotium rolfsii	5	50	10	50
Fusarium lycopersici	5	65	10	65
Fusarium eumartii	10	55	15	55
Sclerotium delphinii	5	50	10	50
Pythium debaryanum	5	40	10	40
Macrosporium solani	30	45	5	50
Botrytis cinerea	10	55	15	55

ture. The maximum time for each temperature was 30 minutes, the tubes being removed at 5 minute intervals. The results are given in Table I.

It might be well at this time to call attention to the work of Kendrick and Gardner (**13**) in which they describe an apparatus to maintain a constant temperature in a water bath, by the addition of ice water or hot water as the need may be, this apparatus being for the purpose of determining the thermal death point. The paper was presented to the Academy meeting in 1922.

Discussion

There are several factors involved in thermal death point determinations which may under certain conditions alter the results. Some of the soil fungi form spores very readily, and the spores, because of their structure, would be able to withstand higher temperatures than the mycelium alone. The majority of the fungi used in this study form spores readily with the exception of *Pythium debaryanum*, in which case only the mycelium was used. In the case of *Sclerotium rolfsii* and *S. delphinii*, only the sclerotia were used, as they are quite large and easily handled.

All of the fungi studied were grown in pure culture on potato dextrose agar. It is quite possible that some of them might have developed into more resistant forms if grown on some other culture medium.

The technique could also be improved, I think, by the use of a liquid culture medium such as Richard's or Czapek's in the test tubes instead of the sterile distilled water, as the entire contents of the tube were poured on the agar plate. There is a possibility that the water on the agar plug may have had a tendency in some cases to inhibit the growth of both spores and mycelium.

The recommendation is generally made that greenhouse soil to be sterilized should be subjected to a temperature of 180° F. or 82° C. From the brief results obtained it might seem that this temperature could be somewhat reduced. However, it must be remembered that these determinations were made *in vitro* in pure cultures. The next step is to make thermal death-point determinations of these fungi in the soil.

The variation in the results for *Fusarium lycopersici* may be due to the fact that in the first test uniform sections of agar plus mycelium, 6 mm. in diameter were used, while in the second test the sections of agar and mycelium were not of uniform size. This also holds true for *Fusarium eumartii*, which gave a result of 45° C. for 20 min., using the uniform size, but was contaminated and therefore was not included in the results. Uniform sections were used, however, with Pythium, Macrosporium, and Botrytis, the diameter in the first two being 9 mm. and 6 mm. in the latter.

Bibliography

1. Bewley, W. F. and W. Buddin, 1921. On the fungus flora of glasshouse water supplies in relation to plant diseases. Ann. of Appl. Biol. **8**:10-19.

2. Brown, H. D., I. L. Baldwin, and S. D. Conner, 1922. Greenhouse soil sterilization. Purdue Univ. Agr. Exp. Sta. Bul. **266**.

3. Byars, L. P. and W. W. Gilbert, 1920. Soil disinfection with hot water to control the root-knot nematode and parasitic soil fungi. U. S. D. A. Bul. 818.

4. Higgins, B. B., 1927. Physiology and parasitism of Sclerotium rolfsii. Phytopath. **17**:417-448.

5. Jorgensen, C. A., 1933. Tests of soil disinfectants. Tidsskr. for Planteave. **39**:316-328. Rev. Appl. Myc. **12**:709. 1933.

6. Newhall, A. G., 1935. A study of electric soil sterilization. Phytopath. **25**:29-30. (Abstract.)

7. Newhall, A. G. and M. W. Nixon, 1935. Disinfecting soils by electric pasteurization Cornell Univ. Agr. Exp. Sta. Bul. **636**.

8. Newton, W., 1931. Physiology of Rhizoctonia. Sci. Agr. **12**: 178-182.

9. Russell, E. J. and H. B. Hutchinson, 1912. Partial sterilization of soil for glasshouse work. Jour. Bd. Agr. Gt. Brit. **18**:809-826.

————, 1920. Partial sterilization of soils. Jour. Roy. Hort. Soc. (London) **45**:237-246.

10. Scheffer, T. C., 1930. Sterilization of coniferous seed beds. Journ. Forestry. **28**:42-49.

11. Scott, J. C., 1932. How science is harnessing electricity to save horticulture. Flor. Exch. **80**:11.

12. Wallace, G. I. and F. W. Tanner, 1931. Effect of heat on mold spores. Proc. Soc. Exper. Biol. and Med. **28**:970-972.

13. Watanabe, T., 1933. Vitality of Corticium contrifugum parasitic on calabash plant. Bull. Ulsonomiya Agr. Col. Nippon. **3**:17-27.

14. Kendrick, J. B. and Max W. Gardner, 1923. A simple method of determining the thermal death-point. Proc. Ind. Acad. Science. **1922**: 257-258.

ALGAE OF INDIANA: THIRD LIST OF ADDITIONS TO THE 1875-1928 CHECK LIST

C. MERVIN PALMER, Butler University

Algae reported in forty-two papers published between 1875 and 1928 have been enumerated in the Check List of Indiana Algae published by the writer in the Proceedings of the Indiana Academy of Science.[1]

Recently four more papers have been discovered, and, since they add to the check list algae from six more counties and add nine more genera, thirty more species, and a total of 127 additional notations of algae for the state, it seems desirable to include them in a third list of additions to the original 1929 check list. The six counties represented for the first time are Cass, DeKalb, Fulton, Laporte, Porter, and Steuben. The genera and species not previously represented in the check list are indicated below by an asterisk. The paper by Eddy, "The plankton of Lake Michigan" considers forms which were collected in the lake near Gary, Dunes State Park, and Michigan City. According to maps of the state surveyor's office, the counties of Lake, Porter, and Laporte extend out into the lake for some distance. Therefore organisms collected in the lake near the Indiana shore would be in the state.

The algae of Indiana recorded in the four additional papers are given in the following classified list:

GROUP 1. BLUE GREEN ALGAE (CYANOPHYCEAE):

Anabaena. Porter Co. 1927.

Aphanocapsa*. *A. delicatissima* W. and G. S. West, Laporte Co. and Porter Co. 1927. *A. elachista* W. and G. S. West, Laporte Co. and Porter Co. 1927.

Aphanothece. Laporte Co. and Porter Co. 1927.

Chroococcus. *C. dispersus** (V. Keiss) Lemm., Lake Co. and Porter Co. 1927. *C. limneticus** Lemm., Porter Co. 1927. *C. minutus** (Kütz.) Nag., Porter Co. 1927.

Coelosphaerium. *C. kützingianum* Nag., Laporte Co. and Porter Co. 1927.

Lyngbya. Lake Co. and Porter Co. 1927.

Merismopedia. *M. glauca* (Ehr.) Nag., Laporte Co. and Porter Co. 1927.

Nostoc. De Kalb Co. 1895.

Rivularia. Fulton Co. 1910.

GROUP 2. DESMIDS:

Closterium. *C. gracile* Breb., Laporte Co. and Porter Co. 1927.

Cosmarium. Porter Co. 1927.

---

[1] Palmer, C. M., 1929. Algae of Indiana—A classified check list of those published between 1875 and 1928. Proc. Ind. Acad. Sci. 38:109-121.

Palmer, C M., 1931. Algae of Indiana—Additions to the 1875-1928 check list. Proc. Ind. Acad. Sci. 40:107-109.

Palmer, C. M., 1933. Algae of Indiana—Second list of additions to the 1875-1928 check list. Proc. Ind. Acad. Sci. 42:90-92.

GROUP 3. DIATOMS:

Amphiprora*. *A. alata* (Ehr.) Kütz., Laporte Co. and Porter Co. 1927. *A. ornata* Bailey, Porter Co. 1927.

Asterionella. *A. gracillima** (Hantz.) Heib., Lake Co. and Laporte Co. and Porter Co. 1927.

Campylodiscus*. *C. hibernicus* Ehr., Porter Co. 1927.

Cocconeis. *C. placentula* Ehr., Porter Co. 1927.

Cyclotella. Lake Co. and Laporte Co. and Porter Co. 1927.

Cymbella. *C. lanceolata* (Ehr.) Kirch., Porter Co. 1927.

Cystopleura (Epithemia). Porter Co. 1927. *C. turgida* (Ehr.) Kuntze, Porter Co. 1927.

Encyonema. *E. prostatum** (Berk.) Kütz., Porter Co. 1927.

Fragilaria. *F. crotonensis* (Edw.) Kitton, Lake Co. and Laporte Co. and Porter Co. 1927. *F. virescens* Ralfs, Lake Co. and Laporte Co. and Porter Co. 1927.

Gomphonema. *G. acuminatum* Ehr., Porter Co. 1927.

Gyrosigma. *G. acuminatum** (Kütz.) Cl., Porter Co. 1927.

Homocladia. *H. sigmoidea* (Nitz.) Elmore, Porter Co. 1927.

Lysigonium (Melosira). Lake Co. and Porter Co. 1927. *L. granulata** (Ehr.) Ralfs, Laporte Co. 1927. *L. varians* Ag., Lake Co. and Laporte Co. and Porter Co. 1927.

Navicula. Porter Co. 1927.

Sphinctocystis (Cymatopleura). *S. eliptica* (Kütz.) Kuntze, Laporte Co. and Porter Co. 1927. *S. librilis** (Ehr.) Hass, Laporte Co. and Porter Co. 1927.

Stephanodiscus*. *S. niagarae* Ehr., Lake Co. and Laporte Co. and Porter Co. 1927.

Striatella (Tabellaria). *S. fenestrata* (Kütz.) Kuntze, Lake Co. and Laporte Co. and Porter Co. 1927. *S. flocculosa* (Roth.) Kuntze, Laporte Co. and Porter Co. 1927.

Synedra. *S. tenuissima** Kütz., Lake Co. and Laporte Co. and Porter Co. 1927. *S. ulna** (Nitz.) Ehr., Lake Co. and Laporte Co. and Porter Co. 1927.

GROUP 4. ALL OTHER ALGAE:

Ankistrodesmus. *A. falcatus* (Corda) Ralfs, Porter Co. 1927.

Botryococcus. *B. sudeticus** Lemm., Laporte Co. and Porter Co. 1927.

Ceratium. *C. hirundinella* Müll., Laporte Co. and Porter Co. 1927.

Chara. DeKalb Co. and Steuben Co. 1895; Cass Co. 1908; Fulton Co. 1910.

Chlamydomonas. Porter Co. 1927.

Chrysosphaerella*. *C. longispina* Lauter, Laporte Co. 1927.

Coelastrum. *C. microporum* Nag., Lake Co. and Porter Co. 1927. *C. reticulatum** (Dangeard) Senn., Laporte Co. and Porter Co. 1927.

Crucigenia. Lake Co. 1927.

Cryptomonas*. *C. ovata* Ehr., Porter Co. 1927.

Dictyosphaerium. *D. pulchellum** Wood, Lake Co. and Laporte Co. and Porter Co. 1927.

Dinobryon. *D. sertularia** Ehr., Laporte Co. and Porter Co. 1927.

Eudorina. *E. elegans** Ehr., Laporte Co. and Porter Co. 1927.

Euglena. *E. oxyuris** Schmarda, Porter Co. 1927.

Kirchneriella*. *K. obesa* Schmidle, Laporte Co. 1927.

Mesocarpus (Mougeotia). Fulton Co. 1910.

Oocystis*. Porter Co. 1927.

Pediastrum. *P. boryanum* (Turpin) Menegh, Laporte Co. and Porter Co. 1927. *P. duplex* Meyen, Laporte Co. and Porter Co. 1927. *P. simplex* (Bail.), Laporte Co. and Porter Co. 1927.

Phacus. *P. triqueter** (Ehr.), Porter Co. 1927.

Rhizochrysis*. *R. limneticus* G. M. Smith, Laporte Co. 1927.

Scenedesmus. *S. bijuga** (Turpin) Lag., Lake Co. and Porter Co. 1927. *S. quadricauda* (Turpin) Breb., Lake Co. and Porter Co. 1927.

Sphaerocystis. *S. schroeteri* Chodat, Lake Co. 1927.

Spirogyra. De Kalb Co. 1895; Fulton Co. 1910; Lake Co. and Porter Co. 1927.

Trachelomonas. *T. hispida* (Perty), Porter Co. 1927.

Uroglena. *U. americana** Calkins, Lake Co. 1927.

Bibliography

(Titles additional to the original check list and first and second supplements)

1. 1895. Kirsch, P. H. Report upon investigations in the Maumee River basin during the summer of 1893. U. S. Fish Comm. **1894**:315-337.

2. 1908. Evermann, B. W. and H. W. Clark. Lake Cicott, Indiana, and notes on its flora and fauna. Proc. Biological Soc. Wash. (D. C.) **21**:213-218.

3. 1910. Evermann, B. W. and H. W. Clark. Fletcher Lake, Indiana, and its flora and fauna. Proc. Biological Soc. Wash. (D. C.) **23**: 81-88.

4. 1927. Eddy, S. The plankton of Lake Michigan. Illinois, Dept. Registration and Educ., Div. Nat. Hist. Survey. Bull. **17**:201-232.

A FUNGOUS CONTAMINATION OF SHAVING CREAM

C. L. Porter and John Norman Porter, Purdue University

A manufacturing company producing shaving cream reported that it was having trouble with some of the jars of cream developing a brown discoloration.

Jars of the cream were obtained from the company. The discoloration was found to be at the surface and extremely superficial. Examination of the stained soap revealed the presence of a fungal mycelium.

Several fungi were isolated including a brown organism identified as an Aspergillus. This organism was most abundant and most often recovered in isolations. In addition, a green Penicillium, a pink yeast, an Ooidium, a Trichoderma and a bacterial organism occasionally appeared in our isolations. All organisms isolated were grown on potato dextrose agar and cultural and morphological characteristics were studied.

Soaps having had various treatments with respect to sterilization and the addition of antiseptics were obtained from the factory and used as media upon which to grow the fungi previously isolated. As a result of such inoculations it was found that only the brown Aspergillus gave any appreciable growth on a soap medium, and it produced in all cases the characteristic brown stain typical of that in the soap first brought to our attention.

This fungus was identified as an Aspergillus belonging to the ochraceous group. It developed slowly on the soap but eventually covered the surface. The thermal death point was determined as being between 90° and 100° C.

NOTES ON INDIANA GRASSES, 1935

J. E. POTZGER, Butler University

This is the fourth contribution of a series of annual reports on Indiana grasses previously unreported for the counties specified. The nomenclature is that of Deam's Indiana Grasses, 1929. Records prefixed with a star have been reported by Mr. Scott McCoy of Indianapolis.

The writer also gratefully asknowledges the checking of the species reported in this paper by Mr. Chas. C. Deam. A specimen of each grass reported was deposited in the Butler University herbarium.

Agropyron repens (L.) Beauvois. Henry County: edge of ditch near road, 1.5 miles e. of Springport. Madison County: intersection of Highways 67 and 9, waste place along railway embankment. Wabash County: waste place along country road just off Highway 24, quarter mile w. of county line.

Agrostis stolonifera var. *major* (Guadin) Farwell. Johnson County: 4.7 miles n. of Bargersville, old gravel pit along little stream.

Agrostis Elliottiana Schultes. Clinton County: open places along side of ditch and Highway 29, about 3.2 miles n. of Kirklin. Sullivan County:* abandoned field half mile e. of Paxton. Vanderburg County: edge of shallow ditch along Highway 62, half mile e. of Posey County line.

Agrostis perennans (Walt.) Tuckerman. Putnam County: top of wooded bluff along Eel River at U. S. Highway 36, three miles w. of Groveland.

Alopecurus carolinianus Walt. Cass County: rather low old fallow field, .3 mi. e. of Lake Cicott, Highway 24. Marion County: waste places along edge of Butler Botanical Garden. Sullivan County:* abandoned field half mile e. of Paxton. Warrick County: fallow field, 1 mile e. of Boonville along Highway 62.

Andropogon scoparius Michaux. Bartholomew County: old field along Highway 46, Stony Lonesome, 10 miles w. of Columbus.

Aristida dichotoma Michaux. Monroe County: fallow field, clay hill near Mr. Baxter's farm, 10 miles se. of Bloomington, Salt Creek Township.

Aristida longespica Poiret. Bartholomew County: waste field along Highway 46, five miles w. of Columbus.

Bromus commutatus Schrader. Madison County: edge of Highway 9, half mile s. of Madison-Hancock County line. Morgan County: waste ground, hill with scattered trees, 3 mi. sw. of Morgantown.

Bromus japonicus Thunberg. Brown County: edge of Highway 46, 1 mile s. of Bean Blossom. Clinton County: edge of ditch and Highway 29, 2.3 miles n. of Boylston. Henry County: edge of Highway 3 and a little creek, 1.3 mi. s. of Springport. Morgan County: 2 miles w. of Centerton, edge of road just across Sycamore Creek. Wabash County: waste place around road through field just off Highway 24, about one-fourth mile w. of county line.

Bromus purgans L. Lagrange County: boggy place along country road, 3 miles s. of Brushy Prairie. Steuben County: open places in oak woods, sandy soil above bog, east of Hogback Lake.

Bromus purgans forma *laevivaginatus* Wiegand. Johnson County: open woods near road, 3 miles s. of Trafalgar. Lagrange County: oak-hickory woods half mile e. of Adams Lake. Morgan County: Highway 35 and edge of ditch, .3 miles sw. of Morgantown.

Bromus secalinus L. Clinton County: 3.2 miles n. of Kirklin, along fences, roadsides, Highway 29. Henry County: edge of Highway 3 and ditch, 1.3 miles s. of Springport. Johnson County: roadside ditch, 3 miles s. of Trafalgar. Marion County: edge of field and low ground, beech woods, Spann woods half mile n. of Kessler Boulevard, mile w. of Crow's Nest.

Bromus tectorum L. Franklin County: low fields, roadsides, common along Highway 52, 1 mile w. of Metamora.

Cinna arundinacea L. Brown County: low woods along Salt Creek, 2 miles n. of Gnaw Bone. Madison County: open woods, south side of Road 36, 3.3 mi. w. of Emporia.

Dactylis glomerata L. Cass County: along railway embankments, 3 miles w. of Lake Cicott. Clinton County: 2.2 miles n. of Michigantown, edge of ditch and Highway 29. Spencer County: along high bank at eastern edge of St. Meinrad, along Highway 62. Warrick County: along side of road, 1 mile east of Boonville, Highway 62.

Danthonia spicata (L.) Beauvois. Morgan County: edge of woods and dry clay upland, 1.5 miles w. of Centerton.

Diarina festucoides Rafinesque. Madison County: open woods south side of Road 36, 3.3 mi. w. of Emporia.

Digitaria Ischaemum Schreber. Brown County: waste places along road at foot of ridge below Dr. Smith's cabin, half mile w. of U. S. Highway 35, at Whippoorwill's Nest.

Echinochloa crusgalli (L.) Beauvois. Henry County: roadside, 1 mile n. of Dunreith, Highway 3. Johnson County: 4.7 miles nw. of Bargersville, old gravel pit along little stream. Marion County: waste place along edge of Bacon's Swamp at 56th street, Indianapolis.

Elymus canadensis L. Huntington County: side of road, near Silver Creek, along Highway 24.

Elymus riparius Wiegand. Brown County: low woods along Salt Creek, 2 miles n. Gnaw Bone.

Elymus virginicus var. *glabriflorus* (Vasey) Bush. Henry County: edge of country road and ditch, 2.5 miles n. of bridge over upper Blue River, half mile n. of Springport road.

Eragrostis cilianensis (Allioni) Link. Hancock County: field, city park at Fortville. Henry County: roadside at junction of Highway 36 and Blue River, 1.8 miles e. of Mt. Summit. Marion County: waste places along road leading from 59th street, Indianapolis, to west approach of Bacon's Swamp.

Eragrostis hypnoides (Lamarck) BSP. Marion County: wet boggy soil at Bacon's Swamp, at 56th street, Indianapolis.

Eragrostis pectinacea (Michaux) Nees. Madison County: roadside along Highway 36, 4.4 miles w. of Emporia.

Eragrostis spectabilis (Pursh) Steudel. Brown County: waste field on Dr. Smith's estate, hillside just below his cottage, half mile w. of U. S. Highway 35.

Festuca elatior L. Hamilton County: edge of highway and ditch, 2 miles se. of junction of Highways 32 and 38 on 38.

Festuca octoflora var. *tenella* Fernald. Morgan County: along sand mine railway tracks, sandy soil near chutes for unloading, 1 mile e. of Highway 67.

Festuca rubra L. Marion County: margin of woods and lawn, 3711 N. Gladstone Ave., Indianapolis.

Glyceria plicata Fries. Noble County: waste lowland area overgrown with buttonbush, 1 mile nw. of Wolf Lake.

Hordeum jubatum L. Hancock County: roadside, half mile s. Madison-Hancock county line along Highway 36. Madison County: roadside, half mile e. of Madison-Hancock county line.

Holcus lanatus L. Henry County:* edge of road through woods in Memorial Park, 1 mile n. of Newcastle, on Highway 3.

Hystrix patula Moench. Montgomery County: lowland woods in Pine Hills, near Indian Creek.

Koeleria cristata (L.) Persoon. Cass County: sandy hill in old cemetery, w. of cottages at Lake Cicott.

Leersia oryzoides (L.) Swartz. Hancock County: flood-plain of small stream in Fortville city park.

Lolium multiflorum Lamarck. Marion County: first report for the state; lawn of Mrs. B. F. Aufderheide, 4012 N. Broadway, Indianapolis.

Muhlenbergia brachyphylla Bush. Henry County: roadside along Highway 3, 1 mile n. of Dunreith.

Muhlenbergia foliosa Trinius. Greene County: roadside embankment, 2 miles sw. of Worthington.

Muhlenbergia mexicana (L.) Trinius. Hancock County: flood-plain of small stream in Fortville city park. Madison County: open woods, south side of Road 36, 3.3 miles w. of Emporia.

Muhlenbergia Schreberi Gmel. Madison County: roadside along Highway 36, 4.4 miles w. of Emporia.

Muhlenbergia tenuiflora (Willd.) BSP. Brown County: young, dense oak woods, 1 mile south of Bean Blossom, half mile e. of Highway 35, on first country road out of Bean Blossom.

Panicum Boscii Poiret. Montgomery County: terrace above Indian Creek, below Devil's back bone, Pine Hills.

Panicum capillare L. Bartholomew County: waste field along Highway 46, 5 miles w. of Columbus. Henry County: roadside along Highway 3, 1 mile n. of Dunreith.

Panicum clandestinum L. Morgan County: edge of road to field crossing Sycamore Creek, 2 miles w. of Centerton. Montgomery County: first terrace above Indian Creek, below Devil's Backbone, Pine Hills. Sullivan County:* edge of abandoned field, half mile e. of Paxton.

Panicum dichotomiflorum Michaux. Marion County: waste place along road from 59th street, Indianapolis, to western entrance of Bacon's Swamp. Bartholomew County: waste field along Highway 46, five miles w. of Columbus. Hancock County: old field, Fortville city park. Henry County: roadside along Highway 3, 1 mile n. of Dunreith. Madison County: roadside along Highway 36, 4.4 miles w. of Emporia.

Panicum dichotomum L. Montgomery County: dry upland on the backbones in Pine Hills.

Panicum huachucae Ashe. Parke County: dry roadside bank at Roaring Creek, 6 miles n. of Rockville on Road 41. Hamilton County: edge of open woods densely overgrown with grass, 1.3 miles sw. of railway overhead crossing, near Noblesville. Madison County: waste place along railroad right-of-way, along Highway 67 opposite the State Reformatory. Morgan County: dry fallow field, clay soil, 1.5 miles w. of Centerton, near cliff on Sycamore Creek.

Panicum Lindheimeri Nash. Marion County: sandy waste field above Bacon's Swamp, near 58th Street, Indianapolis, west side of swamp.

Panicum linearifolium Scribner. Steuben County: gravelly sandy ridge, east side of road, east side of Hogback Lake. Cass County: sandy ridge in old cemetery, west of cottages, at Lake Cicott and Highway 24.

Panicum sphaerocarpon Elliott. Brown County: waste field below Dr. Smith's cottage, 1.5 miles s. of Bean Blossom, half mile w. of Highway 35. Monroe County: waste upland field at Cedar Cliffs, western edge.

Phalaris arundinacea L. Cass County: low place along railway tracks, .3 mile e. of Lake Cicott.

Phleum pratense L. Cass County: cut through gravel and sand hill, Highway 24, 3 miles w. of Logansport. Clinton County: 3.2 miles n. of Kirklin, along fence and between Highway 29 and ditch. Henry County: edge of ditch and road, 1.5 miles e. of Springport.

Poa annua L. Madison County: waste places along Highway 9 in Pendleton. Posey County: lawn at World War Memorial in Mt. Vernon. Warrick County: fallow upland field, 1 mile e. of Boonville.

Poa Chapmaniana Scribner. Marion County:* waste places at 36th St. and Graceland, Indianapolis. Sullivan County:* abandoned field, half mile e. of Paxton. Warrick County: fallow upland field, 1 mile e. of Boonville.

Poa compressa L. Henry County: edge of little creek, 1.3 miles s. of Springport, along Highway 3.

Poa pratensis L. Clinton County: along fences and ditches, 3.2 miles n. of Kirklin, Highway 29. Crawford County: roadside along Highway 37, three miles n. of Sulphur. Franklin County: open field near little creek, half mile south of U. S. Highway 52, about 3 miles w. of Metamora.

Marion County: edge of walk along upper edge of canal bank, Butler University Campus, Indianapolis. Perry County: along little creek, in a fallow field, 1.9 miles e. of St. Meinrad, along Highway 62. Vanderburg County: edge of ditch running through a field, .6 mile e. of Posey County line, Highway 62. Warrick County: roadside, 1 mile east of Boonville.

Poa sylvestris Gray. Franklin County: beech-maple woods, along edge of intermittent stream, north side of U. S. Highway 52, 3 miles w. of Metamora.

Setaria lutescens (Weigel) Hubbard. Henry County: roadside along Highway 3, 1 mile n. of Dunreith. Madison County: field on east edge of woods, along Highway 3, about 3.3 miles w. of Emporia. Marion County: fallow field above Bacon's Swamp, Indianapolis. Wabash County: waste places along old road, just off Highway 24, quarter mile w. of county line.

Setaria viridis (L.) Beauvois. Cass County: roadside along Highway 24, 1 mile w. of Lake Cicott.

Sorghastrum nutans (L.) Nash. Henry County: seeping bog in park, 2.6 miles n. of Newcastle. Huntington County: railway embankment, east side of Silver Creek, along Highway 24.

Sphenopholis obtusata (Michaux) Scribner. Cass County: wet area along fence, just north of old pond, half mile w. of Lake Cicott.

Sphenopholis pallens (Sprengel) Scribn. Perry County: along fence in fallow field, 1.9 miles e. of St. Meinrad, Highway 62.

Sporobolus asper (Michaux) Kunth. Hancock County: roadside bank, Highway 67, mile w. of Fortville. Madison County: roadside at junction of Highways 67 and 9.

Sporobolus vaginaeflorus (Torrey) Wood. Henry County: roadside along Highway 3, 1 mile n. of Dunreith.

Stipa spartea Trinius. Cass County: sandy ridge in old cemetery, w. of cottages, at Lake Cicott.

NOTE ON A SEEDLING VARIATION IN SUNFLOWER

C. A. Ludwig, Washington, D. C.

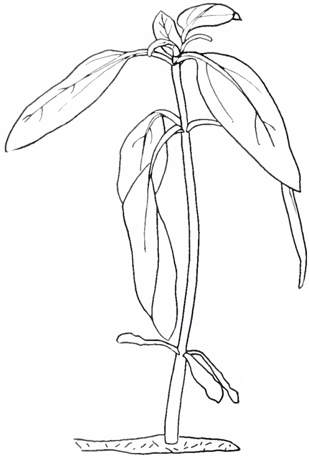


Fig. 1. Seedling sunflower with three cotyledons.

In the winter of 1931 the writer found among seedlings of sunflower (*Helianthus annuus* L.), grown from seed from a local seed store, one plant which had three cotyledons and three leaves instead of the usual two at the first few nodes (Fig. 1). This sort of variation is fairly common and has been mentioned in the literature. The writer has observed it often, particularly in alfalfa.

Since he had not seen any statement concerning the heritability of such variations in the sunflower, this plant was transplanted into a large jar and placed out of doors for further observation. After some vicissitudes it matured a small head filled with small but plump seeds.

These seeds were the result of self-pollination, for, while the flowers were not artificially pollenized, the plant was grown at a great distance from all other sunflowers and flowered out of season. If, therefore, the peculiarity under study were the expression of a simple heritable dominant factor, it would be expected that either approximately three-fourths or all of the immediate progeny should show it; if it were recessive, all of the progeny should show it.

The seeds were planted in the garden in 1932, but none of the plants showed the variation in question. Twenty-one reached maturity under conditions which permitted cross pollination among themselves, and perhaps to a very minor extent, among other plants of the same species. Due to late planting, the plants and the heads produced were small.

The seeds of these plants were planted in 1934, and some thousands of seedlings were secured, ranging in number from a very few to several hundred per plant of the preceding crop. None of these had three cotyledons.

Except for the unlikely possibility that outside conditions prevented the variation, these two seasons' examinations definitely dispose of the possibility that this is a simple heritable variation. They do not eliminate the possibility of a multiple-factor situation, since the number of plants in the first generation was conceivably too small to obtain the few variant plants which might be expected. This possibility seems remote, however, especially since no plant with the peculiarity was detected among the thousands of individuals in the second progeny where some such would be expected, even in the absence of any in the immediate progeny.

The evidence from this work is, therefore, that the three-cotyledon variation of sunflower which was studied is not heritable.

PROGRAM OF THE SECTION ON CHEMISTRY AND BACTERIOLOGY

Chairman: M. G. **MELLON**, Purdue University

1. *The refractive indices of solutions of electrolytes in non-aqueous solvents. Frank E. Dolian and H. T. Briscoe, Indiana University.

2. *The chemical composition of the fatty oil from Kukui nuts. J. L. Riebsomer and Nathan Foote, DePauw University.

3. *Volumetric determination of the percentage of oxygen in air by high school students. C. O. Pauley, Valparaiso.

4. Rabies: the relation of the M. L. D. to the protein content. C. A. Behrens and J. F. Barker, Purdue University.

5. Purification of suspensions of the virus of rabies. C. A. Behrens and J. F. Barker, Purdue University.

6. *Increasing recognition of the importance of tryptophane as a prototype in phytochemical processes. W. M. Blanchard, DePauw University.

7. Some unusual food toxins. R. H. Carr, Purdue University.

8. *Commercial production of sterile vaccine virus. Howard C. Allisbaugh and L. C. Morgan, Eli Lilly & Co.

9. *On the enhancement of bacterial virulence by gastric mucin. Ruth Henderson, W. A. Jamieson, and H. M. Powell, Lilly Research Laboratories.

10. *The preparation of alkyl bromides from corresponding alcohols by the use of bromine in the presence of phosphorus. R. H. Goshorn and Ed. F. Degering, Purdue University.

11. Laboratory gadgets. Ed. F. Degering, Purdue University.

12. That first chemistry lecture. R. E. Nelson and Ed. F. Degering, Purdue University.

13. *Studies in the indole series. VII. Alpha-propyl- and alpha-hormoveratryl-indole. P. L. Julian and Josef Pikl, DePauw University.

14. *Contribution to the chemistry of tryptophane. F. M. Miller and R. E. Lyons, Indiana University.

15. *A rapid procedure for the Duclaux analysis of dilute mixtures of formic and acetic acids. F. O. Gibson and W. E. Bradt, State College of Washington.

16. *The effect of sodium ortho phenyl phenate on viscosity, jelly strength, and adhesive strength of glue. I. F. Fleischer and R. J. Hartman, Indiana University.

Papers No. 14, 15, and 16 were read by title. Title no 16 was received too late for publication in the program of the meeting. The paper by L. A. Test and F. J. Allen, on A Century of Chemical Education in Indiana, which was presented in the General Section (See Program, p. 9), is published here.

---

*Papers published in this volume.

THE REFRACTIVE INDICES OF NON-AQUEOUS SOLUTIONS OF METALLIC CHLORIDES

Frank E. Dolian and H. T. Briscoe, Indiana University

The refractive indices of solutions have been only slightly considered during the last few years, and information in this direction concerning non-aqueous solutions is especially rare. The authors have collected the following data on the subject and believe that they are worthy of consideration and an attempt at interpretation. We have been concerned primarily with the effect of salts of different types upon the refractive properties of closely related, yet distinctly different, solvents. Ethyl alcohol, methyl alcohol, and water were used as solvents. The salts were of two kinds: (1) Di-univalent salts, such as cupric chloride; and (2) tri- and quadri-univalent salts, aluminum, ferric, and stannic chlorides. Because of limited solubilities and of reactions with the solvent, it was not possible to study each salt in each solvent.

All measurements were made on a Zeiss-Pulfrich refractometer. The value of *N*, the refractive index, $\triangle N$, the refractive index increment, and *R*, the specific refraction, were calculated in the usual manner for a temperature of 25° C. Our measurements were made by using the D-line of the sodium spectrum.

Experimental

Materials. Absolute ethyl alcohol was prepared by treating one liter of 95 per cent grain alcohol first with 5 ml. of concentrated sulphuric acid, and then three times with 300 gms. of freshly prepared quicklime, 25 gms. of lead acetate being added with the third portion of lime. A distillation was made between each of the above steps, and the final product was redistilled through an efficient fractionating column. The first and last 100 ml. of distillate were discarded. Absolute methyl alcohol was prepared in essentially the same manner. Absolute ethyl acetate was distilled once from fused calcium chloride to remove any moisture present. Pure acetic acid was prepared from a good grade of glacial acetic acid by fractional crystallization.

Pure stannic chloride was made by distillation from a mixture of its hydrate, $SnCl_4 \cdot 5H_2O$, and concentrated sulphuric acid. Ferric chloride was prepared by passing chlorine over heated iron filings. Aluminum chloride was purified by sublimation. The remainder of the salts were prepared by dehydrating the purest salts obtainable. The usual precautions were taken to protect all of these materials from atmospheric moisture during storage.

Results. The refractive indices, the rates of increase of the index with increasing concentration of salt, and the specific refractions for the solutions studied are given in the accompanying tables (Tables I-V).

TABLE I

SOLUTIONS IN ETHYL ALCOHOL

Concentration—Weight Fraction	$n_d^{25°}$	$\triangle n_d^{25°}$	r
CUPRIC CHLORIDE—			
0.00000	1.358320	0.000000	....
0.00526	1.359032	0.000712	0.1297
0.01050	1.359744	0.001424	0.1772
0.02028	1.362068	0.003748	0.1514
0.04134	1.365126	0.006806	0.1590
0.07957	1.371798	0.013478	0.1416
MERCURIC CHLORIDE—			
0.00000	1.359437	0.000000	....
0.01008	1.359614	0.000177	0.0294
0.01996	1.360622	0.001186	0.0563
0.04164	1.362056	0.002620	0.0753
0.08035	1.365236	0.005800	0.0806
0.15020	1.370958	0.011522	0.0818
NICKEL CHLORIDE—			
0.00000	1.359820	0.000000	....
0.00192	1.360710	0.000890	0.0183
0.00382	1.361427	0.001607	0.0000
0.00757	1.362860	0.003040	−0.0385
0.01492	1.365841	0.006021	−0.0226
CADMIUM CHLORIDE—			
0.00000	1.359823	0.000000	....
0.00393	1.360357	0.000534	0.1193
0.00784	1.360713	0.000890	0.1172
0.01557	1.361250	0.001427	0.0952
0.03072	1.363220	0.003397	0.1075
FERRIC CHLORIDE—			
0.00000	1.358577	0.000000	....
0.00424	1.359645	0.001068	0.2274
0.00845	1.360713	0.002136	0.2189
0.01679	1.362414	0.003837	0.2166
0.03313	1.365753	0.007176	0.2044
0.06454	1.372345	0.013868	0.1969
ALUMINUM CHLORIDE—			
0.00000	1.359378	0.000000	....
0.00380	1.360357	0.000979	0.1504
0.00757	1.361070	0.001692	0.1414
0.01501	1.363040	0.003662	0.1515
0.02955	1.366845	0.007467	0.1534
0.05734	1.374195	0.014817	0.1549
STANNIC CHLORIDE—			
0.00000	1.358666	0.000000	....
0.00550	1.359601	0.000935	0.1620
0.01095	1.360491	0.001825	0.1703
0.02172	1.361745	0.003079	0.1586
0.04266	1.364075	0.005409	0.1385
0.08242	1.369534	0.010868	0.1368

TABLE II

SOLUTIONS IN METHYL ALCOHOL

Concentration—Weight Fraction	$n_d^{25°}$	$\Delta n_d^{25°}$	r
MERCURIC CHLORIDE—			
0.00000	1.326935	0.000000	....
0.01070	1.328214	0.001279	0.0975
0.02110	1.329270	0.002335	0.0933
0.04150	1.331027	0.004092	0.0883
0.08010	1.334445	0.007510	0.0876
0.14970	1.341260	0.014325	0.0883
CUPRIC CHLORIDE—			
0.00000	1.327095	0.000000	....
0.00530	1.327695	0.000600	0.0367
0.01060	1.328376	0.001281	0.0679
0.02100	1.330344	0.003249	0.1068
0.04100	1.334613	0.007518	0.1296
0.07900	1.342510	0.015415	0.1377
NICKEL CHLORIDE—			
0.00000	1.328207	0.000000	....
0.00940	1.330404	0.002197	0.1193
0.01870	1.332873	0.004666	0.1189
0.03650	1.337933	0.009726	0.1182
0.06990	1.347498	0.019291	0.1230
STANNIC CHLORIDE—			
0.00000	1.327385	0.000000	....
0.00500	1.327760	0.000375	0.0903
0.01000	1.328670	0.001285	0.1381
0.01980	1.329648	0.002263	0.1329
0.03890	1.332490	0.005105	0.1324
0.07550	1.337380	0.009995	0.1333
FERRIC CHLORIDE—			
0.00000	1.327460	0.000000	....
0.00710	1.329195	0.001735	0.1976
0.01440	1.330642	0.003182	0.1573
0.02780	1.333660	0.006200	0.1893
0.05440	1.339630	0.012170	0.1913
0.10430	1.351082	0.023622	0.1937

Discussion of Results

The refractive indices of all the solutions studied were found to be linear functions of the concentration, except for slight abnormalities at low concentrations in the solutions of ferric chloride and stannic chloride in ethyl alcohol and mercuric chloride in methyl alcohol. Similar deviations for ethyl and methyl alcohol solutions of cadmium iodide have been reported by Getman and Gibbons,[1] who attributed them to experimental error. Our ability to reproduce the results that show these abnormalities leads us to believe, however, that they are probably caused by association between solute and solvent or are dependent upon some abnormal

---

[1] Getman and Gibbons, 1915. J. Am. Chem. Soc. 57:1990.

TABLE III

SOLUTIONS IN WATER

Concentration—Weight Fraction	$n_d^{25°}$	$\triangle n_d^{25°}$	r
CADMIUM CHLORIDE—			
0.00000	1.332594	0.000000	....
0.00190	1.332958	0.000364	0.1250
0.00378	1.333270	0.000676	0.1185
0.00760	1.333816	0.001222	0.1392
0.01500	1.334998	0.002404	0.1109
0.02960	1.337180	0.004586	0.1136
NICKEL CHLORIDE—			
0.00000	1.332607	0.000000	....
0.00290	1.333309	0.000702	0.1396
0.00570	1.333894	0.001287	0.1280
0.01140	1.335235	0.002628	0.1463
0.02250	1.337780	0.005173	0.1397
0.04410	1.342910	0.010303	0.1397
ALUMINUM CHLORIDE—			
0.00000	1.332646	0.000000	....
0.00230	1.333270	0.000624	0.1489
0.00470	1.333833	0.001187	0.1484
0.00930	1.335314	0.002668	0.1708
0.01840	1.338100	0.005454	0.1678
0.03610	1.345699	0.011053	0.1731

TABLE IVa

ETHYL ALCOHOL AND WATER

Concentration—Weight Fraction EtOH	$n_d^{25°}$	r EtOH	r H_2O
0.0000	1.332413	....	0.2060
0.1637	1.343657	0.2743	0.2048
0.3436	1.354094	0.2781	0.2048
0.5400	1.360090	0.2784	0.2037
0.7580	1.362681	0.2793	0.2027
0.8757	1.362058	0.2797	0.2046
0.9494	1.360535	0.2801	0.2012
1.0000	1.358933	0.2803	....

effect that involves the ionization of the salt and the independence of its ions.

The belief has been generally held that the members of a series of salts increase the index of refraction in the inverse order of their molecular weights. Our results show, however, that this is not strictly true. Ferric, aluminum, and stannic chlorides are the only salts of those investigated that do not conform to this rule. The abnormalities in the solutions of these salts are always in the direction of a greater increase in the index than that predicted on the basis of molecular weight.

TABLE IVb

ALUMINUM CHLORIDE IN ETHYL ALCOHOL AND WATER

Solvent Composition—mol-fraction H_2O	$AlCl_3$ Concentration mols per liter	$n_d^{25°}$
0.147	0.0000	1.360900
	0.1874	1.368210
	0.3748	1.375036
0.302	0.0000	1.362300
	0.1874	1.369212
	0.3748	1.375318
0.449	0.0000	1.362681
	0.0937	1.366845
	0.1874	1.369948
	0.3748	1.376065
0.685	0.0000	1.360090
	0.0937	1.364030
	0.1874	1.367118
	0.3748	1.373270
0.830	0.0000	1.354094
	0.0937	1.358399
	0.1874	1.361610
	0.3748	1.367846
0.929	0.0000	1.343657
	0.0937	1.345908
	0.1874	1.349205
	0.3748	1.355670

TABLE V

STANNIC CHLORIDE IN ETHYL ACETATE

Concentration—Weight Fraction	$n_d^{25°}$	$\triangle n_d^{25°}$	r
0.00000	1.363040	0.000000	....
0.00390	1.369396	0.006356	0.3894
0.00770	1.371512	0.008470	0.2782
0.01500	1.374009	0.010969	0.2013
0.03070	1.380300	0.017260	0.1687
0.06080	1.391964	0.028924	0.1552

A comparison of the refractive indices of the same salt in different solvents shows that, in general, the order of the rate of increase of the refractive index is greater in water than in methyl alcohol, and greater in methyl than in ethyl alcohol. We are led, therefore, to the conclusion that the refractive index of a solution is increased in proportion to the independence exhibited by the ions of the salt in the solution, since the order of increasing dielectric constants is ethyl alcohol, methyl alcohol, and water. The solutions of mercuric chloride, a salt that ionizes but slightly in any solvent, show the least refractive power of all the solutions studied. The molecular weight of mercuric chloride is probably responsible in part, however, for these results.

The specific refractions of all the salts show only slight abnormalities, and these usually occur in the solutions of the lowest concentrations. They may be due, in whole or in part, to slight experimental errors, which are greatly magnified for dilute solutions in the calculation of specific refractions, because of the small differences in the indices of refraction for these solutions. The following significant fact is to be noted in the majority of the cases: The specific refraction of any one salt approaches a constant value as the concentration is increased, and this constant is approximately the same for the same salt in all the solvents. The extremely small specific refraction in the ethyl alcohol solution of nickel chloride amounts to anomalous behavior of this salt in this solvent. It indicates that a compound is probably formed between these two substances, since the same solutions show similar anomalous results in densities. In this connection, however, it is interesting to note the refractive indices and specific refractions of solutions of stannic chloride in ethyl acetate (Table 5). The solute and solvent undoubtedly combine in these solutions. No values of r differing as widely as those for the stannic chloride-ethyl acetate solutions are found for any salt in alcoholic or aqueous solutions. Hence, chemical combination, or whatever factor is responsible for the effects observed in the ethyl acetate medium, is not a very prominent factor, at any rate, in the solutions with which the major interest of this investigation is concerned.

The specific refractions of water and ethyl alcohol in different mixtures of the two liquids are shown in Table IVa. These are seen to be almost constant throughout the entire range of concentrations but show a definite, although slight, decrease as the concentration of the component decreases. These results confirm, in general, those of Andrews[2] and show a maximum index for the mixture containing 0.42 mole-fraction of water.

The indices of refraction for solutions of aluminum chloride in different mixtures of ethyl alcohol and water are shown in Table IVb. The salt has a much greater effect in increasing the index of the solutions containing large mole-fractions of ethyl alcohol than it has upon those containing the largest mole-fraction of water. The rate of increase in refractive power with increasing concentration of aluminum chlorides is less for all the mixtures than for the single solvent. These results may be interpreted as the effect of the salt in increasing the association between the two solvents.

---

[2] Andrews, 1908. J. Amer. Chem. Soc. 30:358.

THE CHEMICAL COMPOSITION OF THE FATTY OIL FROM KUKUI NUTS

J. L. Riebsomer and N. Foote, DePauw University

The oil[1] examined in this work was expressed from the nuts produced by the kukui tree, *Aleurites moluccana* (L.) Willd., which is indigenous to several of the Hawaiian Islands, India, and China. The kukui tree is small to medium in size, growing as high as sixty feet, and usually grows in the lower mountain zones. Each tree is capable of producing as many as one hundred pounds of the nuts in one season. The nuts have the general shape of an English walnut but possess a thick, hard, ebony-like shell. The average weight of the nuts examined was about twelve grams. The oil is also called lumbang and candle nut oil.

An anonymous writer in the "Oil, Paint, and Drug Reporter" of July 27, 1914, states that there is very little difference between the kukui nuts of Hawaii obtained from *Aleurites moluccana*, and the lumbang nuts of the Philippines obtained from *Aleurites triloba*. West and Montes[2] report an analysis of the oil from the nuts of *Aleurites moluccana* in which they found in part the following characteristics: saponification number, 214; iodine number, 140; linolenic acid 6.5%; linoleic acid 33.4%; oleic acid 56.9%; solid acids, 2.8%. Presumably their oil was obtained from nuts grown on the Philippine Islands. We obtained for the same characteristics of the Hawaian oil: saponification number 191.3; iodine number 162; linolenic acid 5.2%; linoleic acid 61.6%; oleic acid 17.0%; and saturated acids 6.8%. Comparison of these results shows that the oil investigated by us was considerably different in properties from the Philippine oil.

So far as could be learned, no attempt has previously been made to identify and to determine the percentages of saturated acids in kukui nut oil.

Experimental Part

Some of the nuts (including shells) were ground and dried at 105°-110°. The moisture content was 3%. About 16% of the weight of the dried material was extractable with petroleum ether (b. p. 30°-60°). The extract was a slightly yellowish oil. This extracted oil possessed essentially the same physical and chemical characteristics as that which was expressed.

The physical and chemical characteristics of the expressed oil were determined by standard methods and are listed in Table I.

Unsaturated Acids

Preparation and Hydrogenation of Methyl Esters.—The oil was saponified with potassium hydroxide in alcohol solution, and the acids so obtained were separated into the saturated and unsaturated fractions by the lead salt-ether method. The methyl esters prepared from the unsaturated acids distilled from 175°-185° at a pressure of 3.5 mm.

---

[1] Obtained from Hawaii through the courtesy of Mr. N. F. Ambrose, County Extension Agent, Wailuku Maui.

[2] Philippine Journal Science 18:619-635. 1921.

TABLE I. Physical and Chemical Characteristics of Kukui Nut Oil.

Specific gravity (20°/4°)	0.922
Refractive index (Abbe 20°)	1.4785
Iodine number oil (Hanus)	162.0
Saponification value	191.3
Acetyl value	3.2
Acid value	17.4
Reichert-Meissl number	negligible
Mean molecular weight saturated acids	275.7
Mean molecular weight unsaturated acids	288.7
Iodine number saturated acids	15.6
Iodine number unsaturated acids	168.1
Unsaturated acids (basis of oil) (corrected %)	83.8
Saturated acids (basis of oil) (corrected %)	6.8
Unsaponifiable matter %	0.38

Five grams of these esters was reduced catalytically with hydrogen, and the resulting product was saponified and recrystallized from alcohol. The acid had a m. p. of 69°; a mixed m. p. with stearic acid showed no depression. This fact, together with the boiling range of the esters, and the neutral equivalent of the unsaturated acids, indicated that only eighteen carbon atom acids were in this fraction.

Bromination.—The unsaturated acids were brominated qualitatively by the method of Eiber and Muggenthaler.[3] The bromination in ether produced a white precipitate melting at 177°-178°. This indicated the presence of linolenic acid. Removal of the ether and the addition of petroleum ether caused the separation of a precipitate, which after recrystallization from acetic acid melted at 112°. Further crystallization did not raise the melting point appreciably. This material, although not melting at 114° where tetrabromstearic acid should melt, was probably the slightly impure tetrabromo derivative of linoleic acid. Ozonolysis later proved the presence of this acid.

Ozonolysis.—Two hundred and sixty grams of the methyl esters was treated with ozone by the method of Riebsomer and Johnson.[4]

Unfortunately a small but undetermined amount of the material was lost in this process, so that calculations of theoretical yields cannot be made. The ozonized acids were converted to the methyl esters and fractionally distilled as follows, with the pressure at 14 mm.: fraction (1) b. p. 49°-54°, weight 13.5 g.; fraction (2) b. p. 54°-91°, weight 3.6 g.; fraction (3) b. p. 91°-94°, weight 9.1 g.; fraction (4) b. p. 94-143.5°, weight 6.7 g. With the remainder of the distillation at 2.5 mm. the following results were obtained: fraction (5) b. p. 115°-122°, weight 58.6 g.; fraction (6) b. p. 122°-143°, weight 25.7; fraction (7) b. p. 143°-155°, weight 0.7 g.; fraction (8) b. p. 155°-190°, weight 15.1 g.; undistillable 26.9 g.

Since fractions (2) and (4) were small and boiled over great ranges, they were considered to be intermediates and were not further investigated.

---

[3] Lewkowitsch, 1921. Chemical Technology and Analysis of Oils, Fats and Waxes, 6th Ed. Vol. 1, p. 585.

[4] Riebsomer, J. L. and Johnson, J. R., 1933. Jour. Amer. Chem. Soc. 55:3352.

Fraction (1) was saponified and the acid redistilled. The most of this acid boiled at 101°-103° at a pressure of 14 mm., and it was shown to consist of caproic acid: neut. equiv. 116.9 (calcd. 116.1); N_D^{20} 1.4155 (reported 1.4138); D_4^{20} 0.927 (reported 0.929); anilide, m. p. 95°, mixed m. p. with known anilide (m. p. 96°) 95°.

Fraction (3) was saponified and proved to be pelargonic acid: neut, equiv. 157.2 (calcd. 158.1; N_D^{20} 1.430 (reported 1.433); D_4^{20} 0.9078 (reported 0.907); anilide m. p. 56° (reported 57°).

The refractive index and density of fraction (5) were determined: N_D^{20} 1.4360; D_4^{20} 1.0026. These same constants for dimethyl azelate are reported: N_D^{20} 1.436 and D_4^{20} 1.005. A part of this fraction was saponified and the acid recrystallized from hot water: m. p. 105.5° (mixed m. p. with azelaic acid gave no depression); neut. equiv. 94.3. The melting point of pure azelaic acid is 106.5°, and its neutral equivalent is 94.1. These data are sufficient to demonstrate the presence of azelaic acid.

Fraction (6) proved to be largely azelaic acid. Fraction (7) appeared to be impure palmitic acid, which had escaped the lead salt-ether separation process. Fraction (8) was largely unsaturated 18-carbon-atom acids which were not decomposed by ozone.

Finding caproic and azelaic acids in the products of ozonolysis verifies the presence of linoleic acid.[5]

Likewise the finding of pelargonic and azelaic acids indicates the presence of oleic acid. Since linolenic acid was shown to be present by the bromination process, propionic acid should also have been found in the ozonized product, but it was apparently lost in the step for removing the acetic acid and water after hydrolysis of the ozonide. The separation of so small an amount of propionic acid from such a large quantity of acetic acid and water would be a difficult task.

In order to find the percentages of the three unsaturated acids, the thiocyanogen-iodine number[6] of the unsaturated acids was determined. This number was 96.1. Using this figure and the iodine number of the unsaturated acids, the calculation of the percentages of oleic, linoleic, and linolenic acids was made.

	In Unsaturated Fraction %	In Oil % Acid	% Glyceride
Oleic acid	20.3	17.0	17.8
Linoleic acid	73.5	61.6	64.1
Linolenic Acid	6.2	5.2	5.4
	100.0	83.8	87.3

---

[5] Riebsomer, J. L. and Nesty, G. A., 1934. Jour. Amer. Chem. Soc. 56:1784.

[6] Jamieson, G., 1932. Vegetable Oils and Fats. Amer. Chem. Soc. Monograph 58, p. 345.

Saturated acids

About 25 grams of the saturated acids was fractionally crystallized from alcohol. From this process was obtained a less soluble acid with a m. p. of 68°, and its anilide melted at 93°. A mixed melting point with stearic acid (m. p. 69°) and the acid isolated was 68-69°. A mixed melting point of the anilide with known stearic anilide (m. p. 94°) showed no depression.

From the fractional crystallization was obtained a more soluble acid with a m. p. of 61.5°-62° (mixed m. p. with palmitic acid 61.5°-62°), and the anilide prepared from this acid melted at 88°. Palmitic anilide melts at 89°, and a mixed m. p. showed no depression. This evidence established the presence of palmitic and stearic acids in the saturated fraction.

Assuming no other acids present except palmitic and stearic and using the neutral equivalent (275.7), the percentages of these two acids may be calculated.

	In Saturated Fraction	In Oil	
		% Acid	% Glyceride
Palmitic acid	30.7	2.1	2.2
Stearic acid	69.3	4.7	4.9
	100.0	6.8	7.1

Glycerol was shown to be present by the preparation of the tribenzoate.

Summary

1. The physical and chemical characteristics of kukui nut oil have been determined.

2. The oil consists of the glycerides of oleic acid (17.0%), linoleic acid (61.6%), linolenic acid (5.2%), stearic acid (4.7%), and palmitic acid (2.1%), together with a small amount of unsaponifiable matter.

VOLUMETRIC DETERMINATION OF THE PERCENTAGE OF OXYGEN IN THE AIR.—CAN HIGH SCHOOL STUDENTS OBTAIN RELIABLE RESULTS, USING THE PHOSPHORUS METHOD?

C. O. Pauley, Valparaiso High School

Introduction

A great many high school chemistry manuals contain an experiment relative to the amount of oxygen in the air by volume.

The usual plan of procedure may be described as follows: About 50 cc. of air are entrapped in a eudiometer and placed over water that has been allowed to attain room temperature. Levels are adjusted, and the volume is read at room temperature and pressure. The volume of the entrapped air is then reduced to standard conditions. A small piece of phosphorus is inserted into the air column by means of a flexible wire and placed in a fixed position at about the 30 cc. mark. At the next laboratory period (24 hrs. later) the phosphorus is removed, levels adjusted, and the volume of the remaining gases read at room conditions. This volume is then reduced to standard conditions.

Since the phosphorus combines with the oxygen in the air column to form P_2O_5, a compound that is readily soluble in water, a volume of water will rise in the tube during the oxidation period that will equal the volume of oxygen consumed. The per cent of oxygen in the air sample may then be obtained from the following formula:

Per cent oxygen $= \dfrac{V_1 - V_2}{V_1} \times 100$, where V_1 is the standard volume of air sample and V_2 is the standard volume of residue.

High School Students' Results

Many years of service in the high school laboratory have convinced the writer that students not only obtain a variety of results from the above procedure, but that the *average* of their results is far below the established amount of oxygen in the air (21.0% by volume) as it is recorded in text books.

For a number of years I simply ignored these inconsistencies, and ascribed the variations to errors in reading the eudiometers and in calculating results. I have even gone so far as to give a pupil a failing grade on his experiment sheet for a result that was far different from the text book standard. However, wide percentage ranges, year after year, caused me to adopt the rather tedious and laborious plan of reading each eudiometer with the student and then checking his calculations. Another precaution that I have practiced is to have students work the experiment in pairs, thus checking each other before a final verification by the instructor.

This apparently "fool-proof" plan has failed to give results that are appreciably more consistent than those of former years. Table I shows the oxygen determinations that were made by students in Valparaiso High School during the week of October 14-18, 1935.

The students worked in pairs. Eudiometer readings and calculations were made in duplicate and then were verified by the instructor. The water used in the tests had been standing in the room for 48 hours. The phosphorus bits were cut from a piece of phosphorus that had been kept in a sealed can and under water. It appeared to be pure white phosphorus. The thermometers had been tested for freezing point and boiling point accuracy, and the regularity of the temperatures as found by the students showed that there could have been very little inaccuracy from that source. Hence, it would seem that every precaution possible was used to insure accurate and uniform results.

Two of the students' results have been omitted from Table I. One of these showed a percentage of 24.4, and the other, 12.9. These two pairs of students read their eudiometers without being checked by the instructor. Since their findings are far different from the others, I have purposely omitted them. In all, 46 students participated in the determinations shown in Table I.

Table I. Volumetric Determination of the Per Cent of Oxygen in the Air by Phosphorus Method as Calculated by Students in Valparaiso High School

(Each air sample was exposed to phosphorus for 24 hours)

Students worked in couples, each checked his partner's result, and then each result was verified by instructor.

Couple	% Oxygen	Couple	% Oxygen
No. 1	15.5	No. 13	18.9
No. 2	20.3	No. 14	18.7
No. 3	18.3	No. 15	18.5
No. 4	17.5	No. 16	19.2
No. 5	18.3	No. 17	19.1
No. 6	18.2	No. 18	18.5
No. 7	19.3	No. 19	18.5
No. 8	19.2	No. 20	19.4
No. 9	16.4	No. 21	19.1
No. 10	17.4	No. 22	20.3
No. 11	17.9	No. 23	17.4
No. 12	17.3		

Average amount of oxygen in air of chemical laboratory from above data—18.4%.

Instructor's Results

The writer decided to make some determinations of the oxygen content of the laboratory air in order to compare his results with those of the students and also to ascertain the seat of the difficulty, if possible. Since each student's reading had been checked by his partner, and then verified by the instructor, there could be little chance for error in the calculations of the students. Why, then, was there such comparatively wide range of results? Why was each result below the established percentage for oxygen content? Was there some error in the technique? Could it be possible that the oxygen content of the laboratory is below that of ordinary air? The room is occupied just 80 minutes of the day, and then by only about 25 pupils. Besides, it is ventilated by a Johnson forced feed circulation. Hence it would seem that the oxygen content should be very close to normal.

Table II shows the results of my efforts. This study has extended over a period of three weeks. Every possible precaution was used to insure accurate results: eudiometers were cleansed with cleaning solution; each reading was taken over water that had been standing in the room for at least 48 hours; calculations were made by logarithms and checked by slide rule; and levels were carefully adjusted in each trial. I have made several readings of the same sample at different times in order to determine the value of the time factor (See Table II).

TABLE II. Instructor's Results on the Per Cent of Oxygen in Air of Chemical Laboratory, by Volume, Using Phosphorus Method

Same plan of procedure was used as that from which students obtained the results shown in Table I, except that the phosphorus was allowed to oxidize for longer periods of time.

Sample	Oxidation Periods			
	24 Hours	48 Hours	72 Hours	120 Hours
No. 1	19.3%	....	19.4%	....
No. 2	....	....	....	....
No. 3	19.9%	19.5%	19.7%	19.7%
No. 4	*10.3%	19.0%	19.8%	19.3%
No. 5	18.8%	19.9%	18.4%	....
No. 6	18.0%	18.5%	19.0%	....
No. 7	16.7%	18.5%	18.9%	....
No. 8	18.3%	18.1%	18.4%	....
Average	18.5%	18.9%	19.0%	19.5%

(*Not used in average).

Conclusions

1. The period of oxidation as prescribed in manuals is probably too short a time. Three or four days at least, and preferably a week, should be allowed for the oxygen in the tube to be completely consumed.

2. There is some doubt in my mind as to whether this method per-

mits a complete removal of the oxygen in the eudiometer. I have noticed that the piece of phosphorus becomes coated with a brownish coloration. Perhaps this coating prevents free contact between the phosphorus and the air. Further investigation should be made in order to determine the nature of this coloration.

3. Although it may not be possible for high school students to obtain absolutely accurate results in this experiment, yet the procedure affords an opportunity for the student to apply his knowledge of the gas laws in a practical way, and impresses him with the value of accuracy in reading instruments and in making calculations.

4. Since this is one of the few quantitative experiments performed in high school chemistry, it serves as a guide post for the student and assists him in deciding whether or not he is interested in this phase of scientific work.

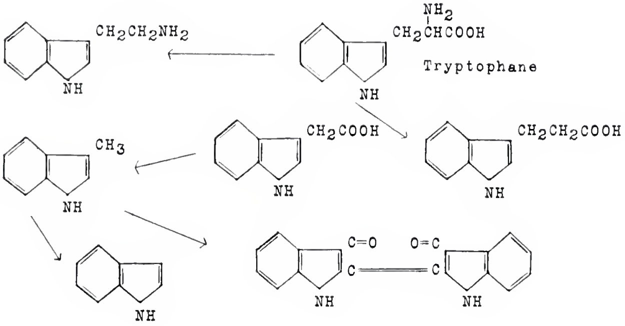
5. The student should not always be censured because he obtains a low percentage of oxygen. Probably sufficient time has not been allowed for complete oxidation of the phosphorus in the sample.

6. Some further investigation should be made as to why the oxidation proceeds much more rapidly in some tubes than in others. I have found cases in which the oxygen was only half exhausted in 24 hours while another would be almost completed in the same time, although the two set-ups seemed to be identical.

INCREASING RECOGNITION OF THE IMPORTANCE OF TRYPTOPHANE AS A PROTOTYPE IN PHYTOCHEMICAL PROCESSES

W. M. Blanchard, DePauw University

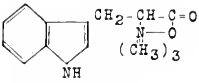
As is well known, tryptophane is an amino acid derived from certain proteins and one of the few amino acids indispensable in the nutrition of higher animals. It was first isolated by Hopkins and Cole (1) in 1901 and afterwards synthesized by Ellinger and Flammand (2) in 1907. Under bacterial action it yields tryptamine, and in the body it undergoes changes which give rise to many substances, some of the most important being illustrated in the following scheme:



The point of particular interest to us just now is the relation of tryptophane to several vegetable alkaloids, and the recent discovery that the powerful alkaloid-like substances found in frogs and commonly known as toad poisons are also tryptophane derivatives. Indeed, it appears that our generally accepted classification of vegetable alkaloids might well be slightly modified to provide for a division to be designated as Tryptophane Alkaloids.

Since two of the members of our teaching staff, assisted by some of our seniors majoring in chemistry, are carrying on investigations in this field, and since their efforts have already met with some success, it seemed to me that it might not be out of order to present to the Academy a brief survey of the advance that has been made in our knowledge of these tryptophane derivatives during the past ten or fifteen years. The topics are not given in strictly chronological order.

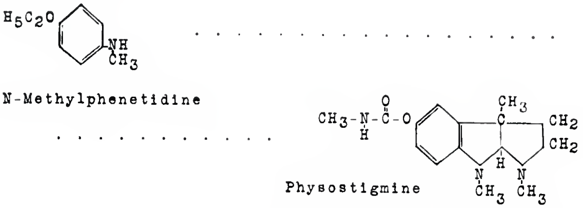
1. *Hypaphorine.* This alkaloid was discovered by Dr. M. Greshoff in 1890, being obtained as a crystalline base from the seeds of *Erythina hypaphorus*, a shade tree grown on the coffee plantations of Eastern Java. In 1911 Pieter Van Romburg and George Barger (3) prepared the betaine of tryptophane by treatment with methyl iodide and sodium hydroxide and proved it to be identical with hypaphorine. Since tryptophane itself can be synthesized, we have here a synthesis of this alkaloid. The drug has only slight physiological action.



Hypaphorine

2. *Physostigmine* (Eserine). It is interesting to note that Java is also the habitat of the Calabar bean which yields this alkaloid. Physostigmine was first obtained from the seeds of *Physostigma venenosum* by J. Jobst and O. Hesse (4) in 1864. It is a valuable drug, a myotic, contracting the pupil of the eye, for example, when it has been dilated by atropine. It is antagonistic to curare in action on the muscles. It stimulates the respiratory center, increases the secretion of the glands and quickens the peristaltic action of the intestines.

Attempts to synthesize physostigmine had been going on in several universities in Europe for more than twenty years but without success until the present year (1935) when a brilliant synthesis was effected in our laboratory by Percy L. Julian and Josef Pikl (5).

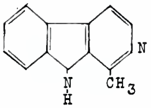


N-Methylphenetidine

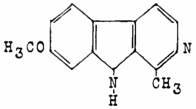
Physostigmine

They start with N-Methylphenetidine and, through a long series of ingenious reactions arrive at their goal, demonstrating the correctness of the formula provisionally assigned to it ten years earlier by Edgar Stedman and George Barger (6). The authors state, "We believe that the route we have taken presents in its essential stages the phytochemical mechanism for the production of this substance."

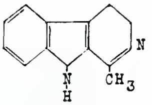
3. *The Harmala Alkaloids.* In 1841 Fr. Goebal described a new dye-stuff which he stated (7) he discovered on December 22nd, 1837, in the seeds of *Perganum harmala* and which he named harmaline. It occurs in the seed in combination with phosphoric acid and is both a



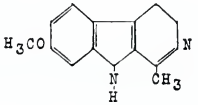
Harman



Harmine



Harmalan



Harmaline

dye and an alkaloid. The plant grows in the South Russian Steppes and in Northern India; it is a very objectionable weed with roots running two or three feet in the ground.

In 1847 J. Fritzsche published a larger work on the constituents of these seeds (8) in which he finds a second alkaloid, also a dye, and which he named harmine. Both of these substances occur in the tegument of the seed, the kernel having only traces.

In 1885 Otto Fischer and Ernst Trauber (9) undertook a more thorough study of these substances, believing them to be quinoline derivatives since they resemble rather closely the synthetic dye-stuffs flavaniline and chrysaniline, which were known to be derivatives of quinoline. But they were unable to verify their supposition. Fischer continued these investigations down to 1914 but without succeeding in determining their structure or effecting their synthesis.

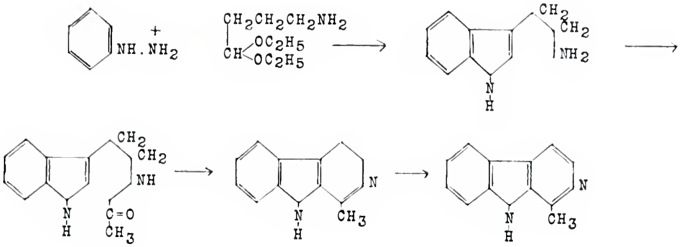
In 1908 William H. Perkin, Jr., and Robert Robinson began a series of studies of these alkaloids, their first paper appearing in 1912 (10), the investigations continuing on down to 1927. In 1919 they proposed for these substances (11) the formulas which were later confirmed on synthetic grounds. Just before this, Otto Fischer (12) prepared what he named *harman* by eliminating the methoxy group from harmine. This substance, harman, he considered the basis of the other two. A little later E. Spaeth showed (13) that harman was also a natural product and identical with the plant bases which had been isolated by O. Hesse and named *aribin* and *loturin*.

Now another interesting fact turns up. In 1928 L. Lewin found (14) that the substance known as *banisterin*, also called *yagein* or *telepathin*, and found in the South American *Liame Banisteria Caapai*, served a valuable purpose in the treatment of influenza. At the same time F. Elger (15) and O. Wolfes and K. Rumpf (16) proved harmine to be identical with banisterin.

In 1927 Richard H. F. Manske, William H. Perkin, Jr., and Robert Robinson (17) described a synthesis of harmaline and harmine which confirmed the formulas already proposed. The steps are long and complicated and will not be given here.

In 1930 Ernst Spaeth and Edgar Lederer (18) presented a new synthesis of these alkaloids which is much simpler, much more likely to be of practical application, and has this additional point of interest, that in the last few steps the reactions seem to be identical with those occurring in the plant photosynthetically. They start with tryptamine which is easily prepared from phenylhydrazine and amino-n-butyraldehydediethylacetal by the method of Arthur Janes Ewins (19). This is converted into N-acetyltryptamine by means of acetic anhydride. On heating this product in xyol with phosphorus pentoxide, water is eliminated, the ring closes and *harmalan* is formed. Harmalan is readily converted into harman by heating with potassium permanganate in sulphuric acid, or more easily, by heating with palladium black for one-half hour at 200°.

Now they start with 3-methoxyphenylhydrazine and by similar reactions synthesize harmaline and harmine.



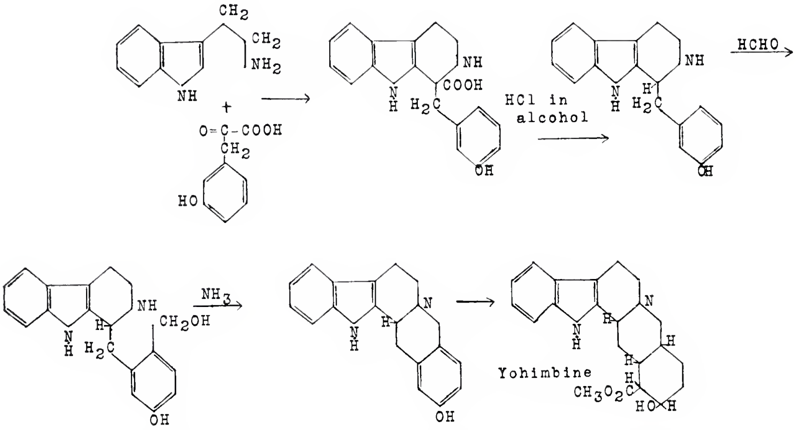
In the same year, 1930, and independently, another synthesis of these substances was carried out by Shiro Akaboni and Kajito Saito (20). They start with tryptamine and 6-methoxytryptamine and synthesize respectively harman and harmine. The ring closure is effected by condensation with acetaldehyde and the reduction is accomplished by heating for several hours in aqueous solution with maleic acid and palladium.

4. *Yohimbine.* In 1896 L. Spiegel obtained from the bark of *Coryanthe yohimba* an alkaloid which he named *yohimbine* and on which he published several papers (21). Many investigations have been carried on in the effort to effect the synthesis and establish the structure of this alkaloid. The synthesis of the frame-work of yohimbine has been accomplished recently, 1934, by Georg Hahn and Henrich Werner (22). Preceding this, in the same year, Georg Hahn, Ernst Kappes, and Hermann Ludewig (23) heated yohimbine with lead tetraacetate (three mols) and obtained tetradehydrogenated yohimbine. When the hydrochloride of this substance was heated one and one-half hours with potassium hydroxide in amyl alcohol, they obtained harman and m-toluic acid. This definitely associates yohimbine with the harmala alkaloids, and hence with tryptophane, and at the same time gives a clue to a possible synthesis of yohimbine.

Now Hahn and Werner (loc. cit) condense tryptaminehydrochloride with m-oxyphenylpyroracemic acid in acetate buffer solution of pH 4.2 in a thermostat at 25°. The p-acid behaves in the same way. The solution was 0.05 molar, the thermostat was of glass, and it stood in the light of a June sun for ten days. A yield of 74 percent of the theoretical amount was obtained. When this product is dried, dissolved in methyl alcohol, and heated for four hours in a stream of dry hydrogen chloride, carbon dioxide is expelled. The hydrochloride of this product is dissolved in a buffer solution of pH 4.4 and treated, on cooling, with 40 percent formaldehyde; there is thereby introduced a CH_2OH group. When this compound is treated in cold solution with ammonia or even with a buffer solution of pH 8, the ring closes, and there is obtained in crystalline form either hexadehydroyohimbol or an isomer. Since the relation of yohimbol to yohimbine had already been determined by Hahn and Stenner (24), this gives us the frame-structure of the alkaloid with only one uncertainty, the position of the hydroxyl group. This is being further investigated.

It is to be noted that in this synthesis, as in that of tetrahydroharman derivatives, at least three of the steps, possibly four, are carried out under physiological conditions. This is most significant.

May I add that we have in progress in our laboratory an investigation which we hope will lead to the synthesis of yohimbine by another method, one that will leave no doubt as to the position of the hydroxyl group.



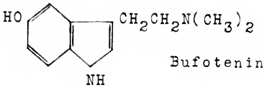
5. *Bufotenine.* In 1902 Edwin S. Faust (25) obtained the substance known as bufotalin from the alcoholic extract of toad skins. The substance was first obtained in crystalline form by Heinrich Wieland and Fried. Jos. Weil (26). It was found to be a lactone and with no nitrogen hence not an alkaloid. According to Faust it is the active compound of the secretion of the skin of the toad and has physiological properties resembling digitalis. Bufotenine seems to have been obtained for the first time by Hans Handovsky (27) in 1920 from *Bufo vulgaris.* It was obtained from the aqueous extract of the toxin after removal of the bufotalin.

In 1912 John J. Abel and David I. Macht (28) obtained from the parotid glands of the tropical toad (*Bufo agna*) two distinct active principles, one adrenaline, the other, a new substance, which they name *bufargin,* an efficient member of the digitalis series. But it contains no nitrogen.

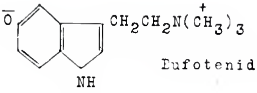
In 1916 Shigematsu Shimizu (29) isolated from the Chinese drug "Senso" another compound which he called *bufotoxin* and which seems to belong to the picrotoxin group of poisons.

Our chief interest lies in bufotenine. Several papers on it have been published by H. Jensen and K. K. Chen (30) and by Heinrich Wieland and co-workers. On biological and pharmacalogical grounds Jensen and Chen soon came to the opinion that bufotenine is a tryptophane derivative.

In 1931 Wieland, Hesse, and Mittasch (31) obtained from the skins of toads a base which they call *bufotenidine* and which they prove to be identical with a base which had already been isolated from Chinese "Senso." From this they obtain bufotenine in pure condition by means of the oxalate. From a careful study of this pure product they give evidence that this alkaloid contains (1) the indole skeleton, (2) a hydroxyl group attached to the indole skeleton, and (3) a dimethyl amine group attached to one of two carbon atoms not forming a part of the indole structure. They show that position (2) in the benzene nucleus is free and hence this hydroxyl group must be in position 4, 5, 6, or 7. Since no natural indole derivatives are known to be hydroxylated in positions 4 or 7 they conclude that the hydroxyl of bufotenine must be in positions 5 or 6. They then synthesize derivatives of both the 5 and 6 type. The methoxyindoles were prepared by the method of Kenneth Guy Blaikie and William H. Perkin, Jr. (32). From these the methoxytryptamines were prepared by the method of Akabori and Suzuki (33). Methylation of the 6-methoxytryptamine with methyl iodide and thallium exthoxide gave a compound which seemed to be identical with that obtained from bufotenine, but the mixed melting point proved otherwise. On methylating the 5-methoxytryptamine they obtained a compound which was shown to be identical with that obtained from natural bufotenine. The conclusion is obvious.

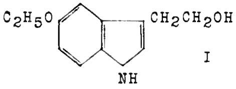


Bufotenine

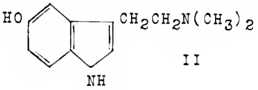


Bufotenidine

Another synthesis of bufotenine has been effected recently by Toshio Hoshino and Kenya Shimodaira (34). They start with 5-ethoxytryptophol (I). This was converted into the corresponding bromide by means of phosphorus tribromide and this into the dimethylamine derivative. On heating this compound with aluminium chloride in benzol they obtained bufotenine (II).



I



II

Again may I state that we have in progress in our laboratory an investigation which we believe will lead to another synthesis of bufotenine, and will give us certain derivatives which we believe will be of pharmacological importance.

Bibliography

1. Hopkins and Cole, 1901. J. Physiol. **27**:418.
2. Ellinger and Flamand, 1907. Ber. **40**:3029.
3. Van Romburg and Barger, 1911. J. Chem. Soc. **99**:2068.
4. Jobst and Hesse, 1864. Ann. **129**:115.
5. Julian and Pikl, 1935. J. Amer. Chem. Soc. **57**:539, 563, 755.
6. Stedman and Barger, 1925. J. Chem. Soc. **127**:247.
7. Goebal, 1841. Ann. **38**:363.
8. Fritzsche, 1847. Ann. **64**:360.
9. Fischer and Trauber, 1885. Ber. **18**:400.
10. Perkin and Robinson, 1912. J. Chem. Soc. **101**:1775.
11. Perkin and Robinson, 1919. J. Chem. Soc. **115**:933.
12. Fischer, 1901. Chem. Centr. 957.

13. Spaeth, 1919. Monatsh. Chem. **40**:351; 1920 ibid. **41**:401.

14. Lewin, 1928. Arch. Exp. Pathol. Pharmakol. **129**:133.

15. Elgar, 1928. Helv. chim. Acta. **11**:162.

16. Wolfes and Rumpf, 1928. Arch. Pharmaz. Ber. Dtsch. Pharmaz. Ges. **266**:188.

17. Manske, Perkin, and Robinson, 1927. J. Chem. Soc. **131**:1.

18. Spaeth and Lederer, 1930. Ber. **63**:120.

19. Arthur J. Ewins, 1911. J. Chem. Soc. **99**:270.

20. Akaboni and Saito, 1930. Ber. **63**:2245.

21. Spiegel, 1903. Ber. **36**:169; 1896. Chem. Zeit. **20**:970; 1897. ibid. **21**:833; 1899. ibid. **23**:59, 81.

22. Hahn and Werner, 1935. Ann. **520**:123.

23. Hahn, Kappes, and Ludewig, 1934. Ber. **67**:686, 2031.

24. Hahn and Stenner, 1928. Ber. **61**:278.

25. Edwin S. Faust, 1902. Chem. Centr. 891.

26. Wieland and Weil, 1913. Ber. **46**:3315.

27. Handovsky, 1920. Arch. Exp. Path. Pharm. **86**:138.

28. Abel and Macht, 1912. J. Pharmacol. and Expt. Ther. **3**:319.

29. Shimizu, 1916. J. Pharmacol. and Expt. Ther. **8**:347.

30. Jensen and Chen, 1925. J. Biol. Chem. **82**:397; 1930. ibid. **87**:741; 1932. Ber. **65**:1310.

31. Wieland, Hesse, and Mittasch, 1931. Ber. **64**:2099.

32. Blaikie and Perkin, 1924. J. Chem. Soc. **125**:296.

33. Akabori and Suzuki, 1929. Bull. Chem. Soc., Japan. **4**:200.

34. Hoshino and Shimodaria, 1935. Ann. **520**:19.

COMMERCIAL CULTIVATION OF STERILE VACCINIA VIRUS

H. C. Allisbaugh and L. C. Morgan, Lilly Research Laboratories, Indianapolis

Since the time of Jenner, nearly 150 years ago, there has been a constant intensive search for a safe and improved virus for the preventive inoculation against small-pox. Vaccinia virus, grown on the calf, having a uniform high potency and a low count of bacterial contaminants, had been the reward until very recently.

Goodpasture and Buddingh (1) described a technique for the cultivation of sterile vaccinia virus on the chorioallantoic membrane of the developing chicken egg. Such a vaccine is free of all bacteria and their toxins. It can be produced easily and quickly, eliminating the necesstiy of long storage. Virus so grown on the developing egg membrane seems less likely to assume neuro-tropic properties than that grown on the calf.

Some modifications of the original technique were necessary for the cultivation of the virus in sufficiently large quantities for commercial distribution. Fertile eggs, not more than 48 hours old, are secured from a selected flock of chickens. Only eggs having well-formed shells are used. On receipt at the laboratory, these are incubated for twelve to fourteen days at 38° C., being turned daily. At the end of this time they are candled and the ones having well-developed embryos are inoculated with the seed virus.

Inoculation

Inoculation can be made by either of two methods.

A. *The shell flap method.* A triangle, one-half inch on a side, is cut through the shell using a small carborundum dental wheel. The shell membrane is cut with a scalpel. The shell flap is then turned back exposing the chorio-allantoic membrane. A small piece of virus-containing tissue is brushed gently over the exposed surface of the membrane. The shell is replaced and sealed with sterile melted paraffin.

B. *The Puncture Method.* A small hole is broken or drilled into the side of the shell, care being taken not to puncture the chorio-allantoic membrane. One-fiftieth of a cubic centimeter of a rich virus suspension is then introduced through the opening with a capillary pippette. The virus spreads over the exterior of the chorio-allantoic membrane. The seed virus used is suspended in 1% saline, since this diluent has a tendency to promote multiple lesions (Rao and Pandit, 2). The opening is sealed with sterile melted paraffin.

Harvesting

After a further incubation of four days, the infected membranes are harvested. The eggs inoculated by the first method are harvested by removing a large section of the shell, including the original flap, and exposing the infected membrane. The lesion surrounded by a border of the membrane is cut off and placed into a sterile Petri dish.

The eggs inoculated by the puncture method are harvested by breaking out the shell over the air-cell, removing the air-cell membrane, and taking out the embryo. The whole chorio-allantoic membrane is then removed from the shell and placed in a sterile Petri dish.

Aseptic technique must be observed throughout the whole procedure. The membranes in each Petri dish are sterility tested on broth fermentation tubes and agar slants, then covered with 50% glycerin containing 1:10,000 Merthiolate.

Grinding

The membranes found to be sterile are aseptically pooled in a large mortar packed in dry ice. While frozen solid they are ground to a fine powder. The desired amount of 50% glycerin is added to the powder and the mixture again tested for sterility on broth fermentation tubes, agar slants and agar pour plates. The potency is determined by serial dilution and inoculation on rabbits. The safety of the product is tested by intra-peritoneal inoculation of mice and guinea pigs.

Filling

The ground lot, if shown to be sterile, is filled and sealed in capillary tubes. The sterility is again tested on broth fermentation tubes, agar slants and agar pour plates. The potency and safety of the virus is again checked by animal inoculation. After the product has successfully passed these rigid tests, it is finished, packaged, and distributed for human immunization.

Discussion

The potency of the average lot of chorio-allantoic vaccinia virus gives a confluent take, on the skin of a shaven rabbit, in a dilution of 1:1000. Any lot which falls below this level is discarded. Passage of the virus in the egg seems to maintain its potency at a uniform level indefinitely without intermediate animal passage. The thermostability of the virus at room temperature or in the refrigerator equals that of calf vaccine virus.

The lesions in human inoculations have been uniformly less severe than those obtained with calf virus. The lesion develops normally but produces a thinner, more superficial scar. Data gathered after several months of production clearly indicate that this vaccine is comparable to the calf vaccine both in primary inoculations and degree of immunity established.

Conclusion

The cultivation of vaccinia virus on the chorio-allantoic membrane of the developing egg, makes possible a sterile immunizing agent of uniform high potency.

References

1. Goodpasture, E. W., and G. John Buddingh, 1935. Am. Jour. of Hyg. **21**:319-360.

2. Pandit, C. G., and R. S. Rao, 1935. Bull. Office. Internat. d'Hyg. Pub. **27**:53-66.

ON THE ENHANCEMENT OF BACTERIAL VIRULENCE BY GASTRIC MUCIN

Ruth Henderson, W. A. Jamieson, and H. M. Powell, Lilly Research Laboratories, Indianapolis

Introduction

Bacterial pathogens of human origin which are either highly virulent or highly toxic for laboratory animals present a ready opportunity for immunological investigation. On the other hand, bacteria of human origin which are neither highly virulent nor highly toxic for laboratory animals offer immediate obstacles to the study of active and passive immunity. Among organisms of this latter group may be mentioned certain of the respiratory bacteria such as meningococci, and certain of the enteric bacteria, such as *B. typhosus*. Except for a low degree of virulence and the ability to produce so-called endotoxin, these organisms are usually entirely without spectacular effect when inoculated into experimental animals. However, their importance as human pathogens demands increased attention to the devising of special methods whereby either high virulence or high toxicity may be exhibited, at least temporarily, in experimental animals.

Nungester, Wolf, and Jourdonais (1) and Miller (2) have devised procedures for augmenting the low-degree mouse virulence which many bacteria naturally exhibit. By coating organisms with a certain form of gastric mucin, it was found possible to bring about perhaps a million fold increase in virulence. This increase in virulence appeared so great and of such promise that experiments were carried out in the Lilly Laboratories, in the winter of 1933-34, to attempt to repeat these original works. These experiments as conducted by Miss Lucille Wade, and as yet unpublished, appeared to verify the original results. However, due to interruption, this study was not continued at that time.

Subsequently Miller (3, 4, 5) and Rake (6, 7) have reported the results of additional experiments on enhancing the virulence of meningococci by use of gastric mucin and attempting to protect animals with antiserum against bacteria of such enhanced virulence. Similar methods and experiments have been applied to *B. typhosus* later by Rake (8).

It is obvious that the mucin coating of human pathogens provides knowledge of certain potential capacities of bacteria otherwise unobtainable and also offers a means for testing of antiserum or actively immune conditions in immunized subjects. For these reasons it appeared of interest to investigate this subject further in this laboratory, dealing with both the meningococcus and the typhoid bacillus.

Experimental

Our experiments on mucin-coating have dealt with the mucin-virulence of meningococci and serum protection tests in mice and mucin-virulence of *B. typhosus* and immunity tests of mice receiving typhoid vaccines.

Mucin Virulence of the Meningococcus. Two groups of cultures available for study were subjected to mucin coating according to Miller (3), using a special lot of mucin from The Wilson Laboratories.

We obtained the first group of cultures from Mr. F. A. Miller of the Lilly Laboratories, Greenfield, Indiana. Cultures "123", "55", "57", and "60" of this group came from the Rockefeller Series and have been cultivated for many years. The other cultures of this group, "331", "173", "146", "302", and "158", have been cultivated from two to four years. Cultures "57" and "302" showed spectacular virulence as noted in Table I. The others were either irregular or of low virulence.

TABLE I

Mucin-virulence of older cultures of meningococci for mice

C.C. of Culture	Culture								
	I 123	I 331	II 55	II 173	III 57	III 146	III 302	IV 158	IV 60
10^{-2}	S D	S S	S D	S S	D D	S S	D D	D D	D S
10^{-3}	S S	S S	S S	S S	D D	S S	D D	D S	S S
10^{-4}	S D	S S	S D	S S	D D	S S	D D	S S	D S
10^{-5}	S D	S S	S S	S S	D D	S D	S D	S S	S S
10^{-6}	S S	S D	S S	S S	D D	S S	D D	D S	S S

Legend: D = Died; S = Survived for 2 days.

The meningococcus strains in the second group were recently isolated. Cultures known as "Rockwell I" and "Rockwell 5" of this group were obtained from Dr. G. E. Rockwell, University of Cincinnati. Cultures known as "M. Smith", "E. Roller", and "L. Thoine", also of this group, were obtained from Dr. G. F. Kempf, Indianapolis City Hospital. The results in Table II show that all cultures of this latter group except "Rockwell 5" exhibit high virulence. It is to be recalled, of course, that the cultures in this latter group had been under cultivation less than a year.

Of a total of fourteen meningococcus cultures tested for mouse virulence, when coated with mucin, six exhibited a high degree of virulence. The recently isolated cultures were the more likely to be virulent; however, one fully virulent culture i. e. "57 III," was found in the oldest group.

TABLE II

Mucin-virulence of newer cultures of meningococci for mice

C.C. of Culture	Culture				
	I Rockwell 1	I Rockwell 5	I M. Smith	I E. Roller	III L. Thoine
10^{-2}	D D	D D	D D	D D	D D
10^{-3}	D D	D D	D D	D D	D D
10^{-4}	D D	S S	D D	D D	D D
10^{-5}	D D	S S	D D	D D	D D
10^{-6}	D D	D S	D D	D D	D D

Legend: D = Died; S = Survived for 2 days.

Serum Protection of Mice Against Mucin-Virulent Meningococci. Serum was obtained from twelve horses being immunized with meningococci. These twelve sera were administered in constant doses of 0.1 c.c. intraperitoneally to twelve series of mice, and one-half hour later each series of mice received graded doses of living mucin-coated meningococci intraperitoneally. The results of these mouse protection tests are shown in Table III. All of the sera showed protection against large multiples of a fatal dose, and about half the sera protected against the largest test dose of culture used, i. e., 0.1 cubic centimeter.

Mucin-Virulence of B. typhosus. Utilizing the same mucin-coating technique as for the meningococcus, we tested the following strains of *B. typhosus:* "220" and "222", separately cultivated, Rawlings strains, used for vaccine preparation; and "Sumori", a freshly isolated culture obtained from Dr. G. F. Kempf. Cultures "Sumori" and "222" exhibited a high degree of virulence while culture "220" was of low virulence for mice as shown in Table IV. The culture "Sumori" appeared to be the best of the three.

Since it appeared rather easy to impart high mouse virulence by mucin-coating certain typhoid bacilli, attempts were made to immunize groups of mice with various vaccines, then after an interval, to subject them to tests with graded doses of living mucin-coated culture. The vaccines used comprised two lots made from culture "220", one lot from

TABLE III

Meningococcus serum mouse protection tests

C.C. of Culture 57 III	Horse Sera												
	732 153	825 156	1198 44	1200 10	1358 7	1375 34	1514 18	1519 17	1671 TB17	1679 10	1750 14	1800 8	Control
10^{-1}	S	S	S	S	D	D	D	D	D	S	S	S	D
10^{-2}	S	D*	S	S	S	S	S	S	S	S	S	S	D
10^{-3}	S	S	S	S	S	S	S	S	S	S	S	S	D
10^{-4}	S	S	S	D	S	S	S	S	S	S	S	S	D
10^{-5}	S	S	S	S	S	S	S	S	S	S	S	S	D
10^{-6}	S	S	S	S	S	S	S	S	D	S	S	S	D

Legend: D = Died; S = Survived for 2 days. *Accident.

TABLE IV

Mucin-virulence of B. Typhosus for mice

C.C. of Culture	Culture		
	Sumori	222	220
10^{-1}	D	D	D
10^{-2}	D	D	D
10^{-3}	D	D	S
10^{-4}	D	D	S
10^{-5}	D	D	S
10^{-6}	D	S	D
10^{-7}	D	D	S
10^{-8}	D	D	S

Legend: D = Died; S = Survived for 2 days.

"222", and one lot from culture "Sumori". These vaccines were made with a turbidity corresponding to a one billion standard.

Immunity Tests of Mice Receiving Various Typhoid Vaccines. In this experiment four groups of mice were immunized subcutaneously with the four vaccines just described. The course of treatment was the same as for humans; however, the dosage was only one-tenth as much; i. e., 0.1 c.c. injections were made instead of 1 c.c. injections. Twelve days after the last dose of vaccine, these four groups of mice, along with a fifth group of normal controls, were subjected to a series of injections of living mucin-coated virulent culture "Sumori". The results in Table V show that the "Sumori" vaccine mice were best protected. In this group it is noted that certain of the weakest doses of test culture killed vaccine-prepared mice presumably of the same degree of immunity as those surviving the larger doses of living culture. No explanation is offered for this.

TABLE V

B. Typhosus vaccine mouse protection test

Test Culture Sumori cc.	220 Vaccine Lot No. 1 Mice	220 Vaccine Lot No. 2 Mice	222 Vaccine Mice	Sumori Vaccine Mice	Normal Controls
10^{-1}	D	D	D	S	D
10^{-2}	D	S	D	S	D
10^{-3}	D	D	D	S	D
10^{-4}	D	D	D	S	D
10^{-5}	D	D	D	D*	D
10^{-6}	D	D	D	D	D
10^{-7}	D	D	D	D	D
10^{-8}	D	D	D	D	D

Legend: D = Died; S = Survived for 2 days. *Accident.

Summary

The results herewith presented corroborate the previous reports by Nungester et al. and Miller and Rake and an unpublished report of Wade. It has been found possible by the mucin technique to increase the virulence of the meningococcus and typhoid bacillus for mice roughly a million times in comparison with previous tests. In most, but not all, cases the newer and fresher cultures were the most likely to be mucin-virulent.

In addition, it has been found that several horse antimeningococcus sera protect mice against mucin-virulent meningococci. In experiments as yet unpublished, we have found that some, but not all, concentrated antimeningococcus sera protect in the same manner, and this agrees with the observations of Miller, as expressed in a personal communication.

In parallel experiments with the typhoid bacillus, we have noted in a comparative way that vaccine made from bacilli of high potential mucin-virulence is most effective in immunizing mice against mucin-virulent typhoid bacilli.

Finally, although the mucin technique may be considered highly artificial, it serves in some instance to differentiate hitherto unrecognized capacities of one culture from another and to assay active immunity by protection against great multiples of a fatal dose of cultures previously considered of a low degree of virulence.

Conclusions

1. Great enhancement of bacterial virulence through use of mucin, has been noted.
2. Serum protection against mucin-virulent meningococci and typhoid bacilli can be measured readily.
3. Conclusions 1 and 2 corroborate and extend the observations of Nungester, Miller, and Rake.
4. It has not been determined what relation, if any, may exist between antibacterial immunity and serum protection against mucin-virulent pathogens.

Bibliography

1. Nungester, W. J., Wolfe, A. A., and Jourdonais, 1932. Effect of gastric mucin on virulence of bacteria in intraperitoneal injections in the mouse. Proc. Soc. Exp. Biol. and Med. **30**:120.

2. Miller, C. P., 1933. Experimental meningococcal infection in mice. Science **78**:340.

3. Miller, C. P., 1935. A study of experimental meningococcal infection I. Method. Proc. Soc. Exp. Biol. and Med. **32**:1136.

4. Miller, C. P., 1935. A study of experimental meningococcal infection II. Course of infection. Proc. Soc. Exp. Biol. and Med. **32**:1138.

5. Miller, C. P., 1935. A study of experimental meningococcal infection III. Effect of anti-bacterial immune serum. Proc. Soc. Exp. Biol. and Med. **32**:1140.

6. Rake, G., 1935. Studies on meningococcus infection. VII. J. Exp. Med. **61**:545.

7. Rake, G., 1935. A method for titrating the protective action of antimeningococcal serum. Proc. Soc. Exp. Biol. and Med. **32**:1175.

8. Rake, G., 1935. Enhancement of pathogenicity of human typhoid organisms by mucin. Proc. Soc. Exp. Biol. and Med. **32**:1523.

THE PREPARATION OF ALKYL BROMIDES FROM THE CORRESPONDING ALCOHOLS BY THE USE OF BROMINE IN THE PRESENCE OF PHOSPHORUS[1]

R. H. Goshorn with Ed. F. Degering, Purdue University

The yields obtained by the use of the hydrogen bromide and phosphorus tribromide methods for the preparation of alkyl bromides from the corresponding alcohols are illustrated in Table I.

Since the phosphorus-iodine method has proven very successful for the preparation of alkyl iodides, it was deemed advisable to test the possible use of a corresponding method for the preparation of the bromides. A procedure was developed for the preparation of ethyl bromide from ethyl alcohol and bromine in the presence of a mixture of red and yellow phosphorus.

As a starting point, ethyl alcohol was treated with bromine and varying amounts of red and yellow phosphorus under different conditions. These separate experiments are tabulated in Table II.

Table I. Yields obtained by using hydrogen bromide and phosphorus tribromide.

Alcohol	Ratio of ROH/HBr	% Yield on Basis of ROH	% Yield on Basis of Br_2	Worker
Methyl	1/3	50	16	Norris[2]
Ethyl	1/3	71	22	Norris[2]
Ethyl	1/3.5	81	22	Norris[2]
Ethyl	1/4	86	20	Norris[2]
Ethyl	1/1.2?	90-95	77	O.S.[3]
Propyl	1/2	59	27	Norris[2]
Propyl	1/4	84	20	Norris[2]
Propyl	....	95	82.5	O.S.(PBr_3)[4]
Iso-propyl	1/3	89	28	Norris[2]
Iso-propyl	....	68	59	O.S.(PBr_3)[4]
Butyl	1/1.2?	95	76	O.S.[3]
Iso-butyl	1/3	30-55	9-17	Norris[2]
Iso-butyl	....	60	52	O.S.(PBr_3)[4]
Sec.-butyl	1/3	95	29	Norris[2]
Sec.-butyl	....	80	69.5	O.S.(PBr_3)[4]
Tert.-butyl	1/1	50	46	Norris[2]
Tert.-butyl	1/2	91	42	Norris[2]
Iso-amyl	1/1	37	34	Norris[2]
Iso-amyl	1/2	78	36	Norris[2]
Iso-amyl	1/3	85	26	Norris[2]
Iso-amyl	1/1.2?	88-90	70-72	O.S.[3]
Tert.-amyl	1/3	95	29	Norris[5]

---

[1] Preliminary report presented before Organic Division of A. C. S., San Francisco, 1935.

[2] Norris, 1907. Am. Chem. J. 38:627.

[3] Org. Syn. 1:1. 1921.

[4] Org. Syn. 13:20. 1933.

[5] Norris, 1916. J. Am. Chem. Soc. 38:1071.

TABLE II. Summary of results using phosphorus.[6]

No.	Order	C_2H_5OH	y. Phos.	r. Phos.	Br_2	C_2H_5Br	%	Bath t°	Stir	Time	Cf.	Set-up	Remarks
1.a.	1	150 a	16	17	189	62	24	70-100	+	......	......	1	Iodine method, using flask.
b.	3	72.5 a (100) a	15	18	(188.5)	197	77	55-100	+	s	......	1	Br_2 added to EtOH below 30°C.
2.a.	2	355 a	30	36	390	372	70	65-110	–	s	......	2	Modified alkyl iodide apparatus.
b(1.	4	145 a (200) a	30	36	(377)	244	47	65-115	–	f	1.b	2	Loss due to too fast addition.
(2.	5	145 a (200) a	30	36	(377)	436	85	80-115	–	s	2.c.1	2	High t°, slower addition.
c.	6	163 (200)	30	36	(377)	410	80	80-115	–	s	1.b	2	Br_2, EtOH mixed below 30°C.
d.	8	163 (200)	30	36	(377)	399	78	80-115	–	s	2.c	2	EtOH added to Br_2 with stirring below 30°C.
3.a.	10	163 (200)	25	41	(377)	417	81	80-115	–	s	2.c	2	y. Phos. decreased r. Phos. increased
b.	12	163 (200)	25	36	(377)	418	81	80-115?	–	s	3.a	2	r. Phos. decreased
c.	14	163 (200)	25	36	(377)	439	85	80-115?	–	s	3.b	2	Carried out in dark.
d.	15	116 (200)	25	36	(377)	412	80	80-115	–	s	3.b	2	Decreased EtOH in flask.
e.	16	116 (200)	25	36	(377)	417	81	90-115	–	s	3.d	3	Higher t° than in 3.d.
4.a.	7	163 (200)	30	36	(377)	382	74	50-95	+	s	2.c	1	Lower t° than 2.d.
b.	9	163 (200)	30	36	(377)	378	74	60-95	+	s	3.b	1	Similar to 4.a except Br_2 added to EtOH.
5.a.	21	363	25	36	377	437	85	85-115	–	2.5	4.b	3	y. Phos. decreased Br_2 added above Phos. layer.
b.	22	363	25	36	377	443	86	85-115	+	3	5.a	3	Stirred during addition.
c.	23	363	25	30	377	445	87	85-115	+	3.5	5.b	3	r. Phos. decreased Br_2 added at surface of Phos. layer.
6.a.	11	163 (200)	25	41	(377)	394	77	80-110	+	s	3.a	3	Distilled during reaction.
b.	13	163 (200)	25	36	(377)	429	83	80-115	–	s	3.b	3	No stirring.
c.	17	163 (200)	25	36	(377)	432	84	90-115	–	s	6.b	3	Higher t° than in 6.b.

7.	19	363	25	36	377	16	3	80–90 65–110	–	s	......	2	160 g. CCl_4+377 Br_2, 80-90°C. Then add 363g. EtOH, 110-65°C.
8.a.	18	363	25	36	377	428	83	85–115	–	s	6.b	3	Attempt to introduce Br_2 below EtOH.
b(1.	20	363	25	36	377	433	84	85–115	–	3	8.a	3	Br_2 introduced below EtOH layer.
(2.	26	363	25	36	377	458	89	90–100	–	s	8.b.1	3	Br_2 introduced below EtOH layer.
c(1.	24	163 (200)	25	36	(377)	331	64?	90–110	–	s	8.b	3	Br_2, EtOH mixed below 20°C., sucked back into flask.
(2.	25	163 (200)	25	36	(377)	426	83	90–110	–	s	8.c.1	3	8.c.1 repeated.
d.	27	163 (200)	25	36	(377)	410	80	90–110	+	s	8.c.2	3	Stirred during reaction.
e.	28	363	20	30	377	454	88	90–110	–	3	8.b.2	3	y. and r. Phos. decreased.
f.	29	363	20	25	377	450	88	90–110	–	3	8.e	3	r. Phos. decreased.
g(1.	30	363	15	25	377	465	90	90–110	–	3	8.f	3	y. Phos. decreased.
(2.	33	363	15	25	377	464	90	90–110	–	3	8.g.1	3	Repetition of 8.g(1.
h.	34	363	15	25	377	457	89	90–110	+	3	8.g.1	3	Stirred during addition of Br_2.
i.	31	363	15	20	377	460	90	90–110	–	3.5	8.g.1	3	r. Phos. decreased.
j.	32	363	10	20	377	449	87	90–110	–	2.5	8.i	3	y. Phos. decreased.
9.a.	35	363	0	40	377	419	82	90–115	–	3.5	......	3	
b	36	363	0	40	377	426	83	90–110	–	3	......	3	
c.	37	363	40	0	377	449	87	90–110	–	3.5	......	3	
d.	38	363	40	0	377	437	85	90–115	–	3	......	3	

---

[6] "a" indicates use of absolute alcohol; 95% alcohol was used elsewhere. Quantities of alcohol and bromine shown in parenthesis were mixed below 30° C., then this mixture added to the alcohol-phosphorus mixture.

Apparatus I consisted of a bolt-head, reflux condenser, dropping funnel and stirrer. Apparatus II was a modified alkyl (Adams) iodide unit, and Apparatus III was similar to Apparatus I, but distillation was carried out during the reaction.

All yields have been calculated on the amount of bromide used.

The procedure for ethyl bromide, as finally adopted, is as follows:

Place 363 g. of 95% ethyl alcohol, 25 g. of red phosphorus, and 15 g. of yellow phosphorus in a three-neck distilling flask.[7] Fit the flask with an Ahlin[8] condenser. By means of a bend of glass tubing connect the top of the Ahlin condenser to a Liebig condenser which dips beneath the surface of ice water in a beaker. The tip of the dropping funnel should be adjusted so that it extends beneath the surface of the phosphorus layer (Fig. 1).

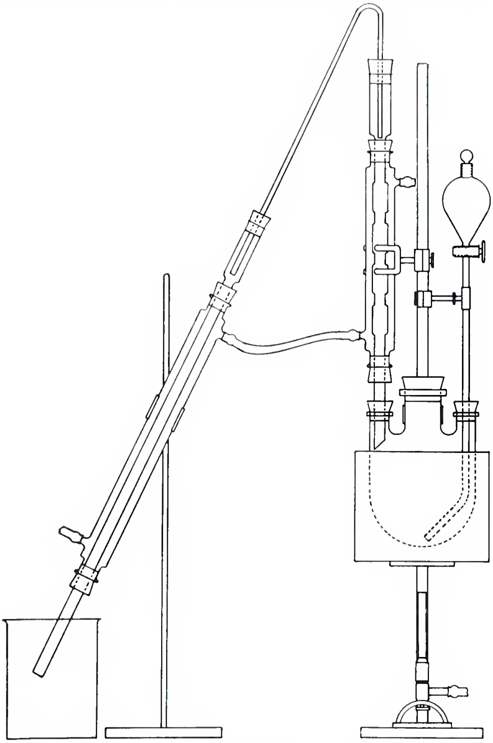


FIG. 1. Apparatus for preparation of ethyl bromide.

The mixture is heated on a water or oil bath until a good reflux is obtained (bath at 100-110° C.). Then 377 g. of bromine is slowly added through the dropping funnel. Vigorous reaction, with some bumping and the formation of white vapors, accompanies the first additions. As the amount of the vapors decreases, the rate of addition of the bromine may be increased to the extent that some of the white vapors are carried over into the Liebig condenser. About three hours are required for the reaction and the bath is allowed to cool slowly to about 90° C.

When the bromine addition has been completed the mixture is allowed to cool and the flask is connected directly to the Liebig condenser.

---

[7] The data in the tables indicate that yellow phosphorus, used alone, gives yields nearly as good as those obtained with the red-yellow phosphorus mixture. With the mixture, however, a much smoother and more readily controllable reaction is obtained.

[8] The lower end of the Ahlin condenser should be cut at an angle to prevent flooding.

Distillation is carried out at the rate of forty to fifty drops per minute up to a temperature of about 94° C. (bath at about 155° C.). This distillate is collected with the previous portion beneath the surface of ice water. Then the entire distillate is washed with 20 c.c. of 5% potassium hydroxide, then with 50 c.c. of water and dried over calcium chloride.

Table III. Yields from butyl alcohols, glycol, and glycerol.

Alcohol	Grams	y. Phos.	r. Phos.	Time Min.	Bromide grams	%	Remarks
n-butyl....	278	7.5	12.5	120	211	66	90-135°, bath temp.
n-butyl....	138	4	6	90	150	93	165-175° bath temp.
n-buytl....	69	0	5	60	57	71	20-25° (H_2O bath) Alc. added to PBr_x with stirring.
sec.-butyl..	138	4	6	30	132	82	125-128° bath temp.
sec.-butyl..	138	4	6	40	137	85	140-150° bath temp.
t-butyl....	278	7.5	12.5	120	56	17	90-105° bath temp.
t-butyl....	138	4	6	20	10	7	0° (ice-water) bath temp.
t-buytl....	69	0	5	60	34	42	Water bath 16-20°. Alc. added to PBr_x with stirring.
Glycol....	58	4	6	60	63	57	Heated with burner.
Glycol....	58	4	6	75	52	47	190-210°, bath temp.
Glycerine..	85.8	6	9	120	56?	34	130-150° Vacuum distilled reaction mixture at 45-55 mm. and vacuum distilled product at 18-20 mm.

(The residue in the flask should be disposed of by pouring it into the hood sink.) The dried product is fractionated and the 37-40° C. fraction collected in a dry receiver packed in an ice-salt mixture. Yield, 455-465 g. or 88-90%.

Similar preparations were made from butyl alcohol, secondary butyl alcohol, tertiary butyl alcohol, glycol, and glycerol, and the following results obtained as shown in Table III.

Apparatus III, with omission of the Liebig condenser, is used for the preparation of the butyl bromides. In the flask are placed 138 g. of butyl alcohol, 6 g. of red phosphorus, and 4 g. of yellow phosphorus.[7] The flask is placed in an oil bath which is brought to a temperature of 175°. Bromine (94 g.) is then added slowly through the dropping funnel, the rate of addition being adjusted so that the dense white vapor which forms remains near the top of the condenser. As the reaction proceeds, the rate of addition is increased and the temperature of the bath is allowed to decrease slowly to 165°. The time required for the reaction is about one hour.

When the bromine addition is complete, the reaction mixture is slowly fractionated through a Vigreux column by heating with an oil bath to a temperature of about 210° C. When the rate of distillation becomes very slow, 25 c.c. of water may be added to carry over the last traces of the product as a constant boiling mixture.

The product is fractionated to remove alcohol, dried with $CaCl_2$, and distilled, giving 150 g. or 93.2% yield of butyl bromide, b.p. 97-99.5°.

The procedure in the case of secondary butyl bromide is similar to that used in the preparation of n-butyl bromide, except that the bromine is added at a bath temperature of 140-150°, and that the distillate from the reaction mixture is washed with water and dried with Na_2SO_4 before redistilling. The yield, b.p. 86-87°, is 137 g., or 85.10%.

Tertiary butyl bromide may be prepared as follows: In a 500 c.c. flask are placed 5 g. of red phosphorus, and 47 g. of bromine are added slowly over a period of 1 to 2 hours, while the flask is cooled with cold water. A mechanical stirrer is then inserted through the large neck of the flask and 69 g. of tertiary butyl alcohol are added slowly (1 hr.) through the dropping funnel.

When the addition of the alcohol is completed, the bromide is distilled through a Vigreux column by heating with an oil bath at a temperature of 70-80°. A slow rate of distillation is maintained by adjusting the pressure, which is gradually decreased to 20 to 24 mm. The product is washed with water, dried with $CaCl_2$, and distilled to give 34.0 g., or 42.2% yield of tertiary butyl bromide, b.p. 69-72°.

The procedure used in the preparation of 1,2-dibromoethane and 1, 2, 3-tri-bromopropane is similar to that used in the preparation of secondary butyl bromide. It should be noted, however, that in the preparation of 1, 2, 3-tri-bromopropane a decreased pressure is used in the distillation of the reaction mixture and in the final distillation of the product.

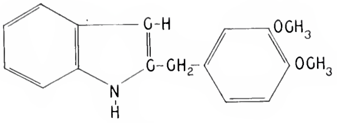
Hence it appears that this method is applicable to the preparation of primary, secondary or tertiary bromides.

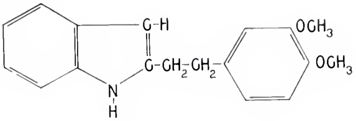
Summary: A method has been developed for the preparation of (1) alkyl bromides from the corresponding alcohols by the use of bromine in the presence of a red and yellow phosphorus mixture, and (2) the method gives satisfactory results for the preparation of primary, secondary and tertiary alkyl bromides.

STUDIES IN THE INDOLE SERIES VII. THE COURSE OF THE FISCHER REACTION WITH KETONES OF THE TYPE R CH_2 CO CH_3. ALPHA-PROPYL AND ALPHA-HOMOVERATRYL INDOLE

Percy L. Julian and Josef Pikl, DePauw University

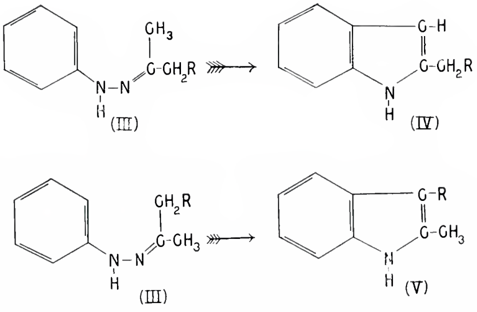
Some time ago, in connection with work on the structures of certain Angostura alkaloids, we desired for purposes of comparison α-Veratryl Indole (I) and α-Homoveratryl Indole (II).


(I)


(II)

Despite the numerous researches on indole derivatives recorded in the literature, no methods were at that time available for securing indoles with elongated mixed aliphatic-aromatic groupings in the α-position.

The well-known Fischer reaction might be expected to yield with the ketones of the type, R CH_2 CO CH_3, a mixture of Indoles (IV) and (V), depending upon whether the methyl or methylene group supplied the requisite hydrogen for ammonia formation; and, indeed, Emil Fischer himself[1] suggested some time ago that the reaction proceeded in both directions. The yield of (IV) was, however, always negligible in comparison with that of (V), as would be expected *a priori.*


(III) (IV)

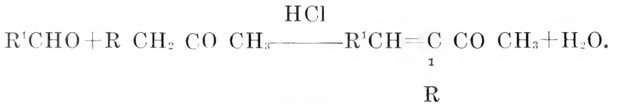
(III) (V)

It was therefore surprising that Arbusow and Friauf[2] should have found that in the case of decomposition of methyl propyl ketonephenylhydrazone with cuprous chloride as catalyst, the principal product is α-propyl indole. It is conceivable that, under varying conditions and with employment of various catalysts, methyl may at one time play the role of yielding hydrogen and methylene at another time, as is the case with condensation between aldehydes and the ketones in question, acids favoring elimination of water by means of the methylene hydrogen, and alkalies doing the same by means of the methyl hydrogen:

---

[1] Fischer, E., 1886. Ann. **236**:133.

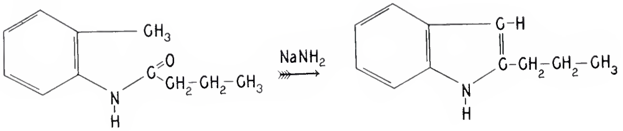
[2] Arbusow, A. E. and Friauf, A. P., 1913. J. Russ. Phys. Chem. Soc. 45:694-696.



$$R'CHO + R\ CH_2\ CO\ CH_3 \xrightarrow{HCl} R'CH{=}\underset{\underset{R}{|}}{C}\ CO\ CH_3 + H_2O.$$

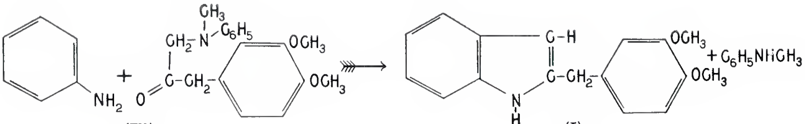
$$R'CHO + R\ CH_2\ CO\ CH_3 \xrightarrow{NaOH} R'CH{=}CH\ CO\ CH_2\ R + H_2O.$$

Nevertheless Arbusow gives no satisfactory proof for the structure of his α-propyl indole, and his work leaves doubt in minds of investigators in this field in view of the description by Verley and Beduwé[3] twelve years later of another compound which they call α-propyl indole. Their α-propyl indole was prepared by elimination of the elements of water from the toluidide of propionic acid by means of sodamide.



Verley evidently overlooked Arbusow's work and consequently makes no comparison of his product with that of the Russian investigator.

For the preparation of alpha benzyl indoles like (I), Julian and Pikl[4] found it necessary to work out a new procedure based upon the reaction between appropriate α-amino-ketones, like (VI), and arylamines.



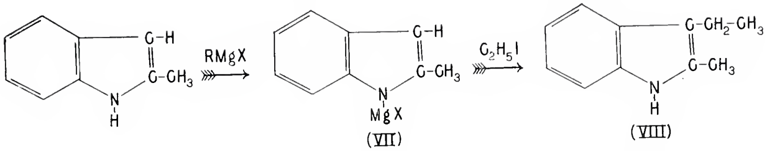
(VI) (I)

Since ketones of the type (VI) had not hitherto been known and were prepared for the first time by Julian and Pikl with somewhat involved reactions,[4] we naturally were interested in Arbustow's preparation of α-propyl indole, for its aromatic analogue, alpha-homoveratrylindole, might be prepared in similar fashion, a preparation which would be much simpler than the method of Julian and Pikl, since the latter method demands at the outset ketones of the type R CH_2 CH_2 CO CH_2X, where X is either halogen or an arylamino residue.

We therefore repeated Arbusow's work. With his so-called "α-propyl indole" in hand the next question was proof of structure. Arbusow had based his formula purely upon the observation that his compound gave the "pine-shaving reaction", characteristic of indoles substituted in the alpha or beta positions, but not of those substituted in both alpha and beta positions. Thus he reasoned that his compound could not be α-methyl-β-ethylindole but must be α-propylindole. We soon found this evidence to be faulty, for when we had carefully purified his compound, it did not give the pine-shaving reaction, and we could only conclude that he secured the reaction because of impurities present in the sample tested. Indeed, we could likewise secure the reaction with all crude preparations before purification. These facts pointed to α-methyl-β-ethyl indole as representing the constitution of his product. Nevertheless more rigid proof of structure was undertaken. For this purpose we decided upon the use of the reaction between an indolylmagnesium halide and an alkyl halide, discovered some years ago by Oddo and his coworkers[5] and employed more recently in synthetic work with much success in the laboratories of Hoshino and Majima.[6] This reaction yields β-alkyl indoles and is illustrated by the reaction between α-methyl indolylmagnesium iodide (VII) and ethyl iodide, the reaction we employed in deciding the constitution of Arbusow's "α-propyl indole".

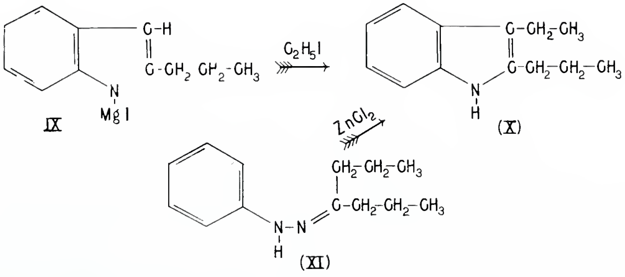
---

[3] Verley, M. A. and Beduwé, J., 1925. Bull. Soc. Chim. (iv) 37:189-191.
[4] Julian, P. L. and Pikl, J., 1933. J. A. C. S. 55:2105.



This reaction led to an indole (VIII) identical in every respect with Arbusow's compound. His substance is therefore not α-propyl indole but α-methyl-β-ethyl indole.

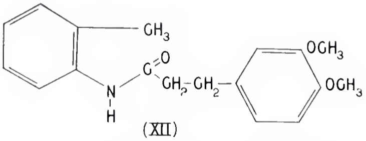
This leaves as the only other compound described in the literature which might be alpha-propyl indole, the one prepared by Verley. That it is actually α-propyl indole we have proved in similar fashion. Thus α-propyl indolylmagnesium iodide (IX) gave on treatment with ethyl iodide α-propyl-β-ethyl indole (X). To synthesize (X) by another and unequivocal route, di-n-propyl ketonephenylhydrazone (XI) was prepared and subjected to the Fischer reaction, yielding a substance indentical with (X) secured from Verley's α-propyl indole. Thus Verley's preparation is the only case without question where α-propyl indole has actually been synthesized.



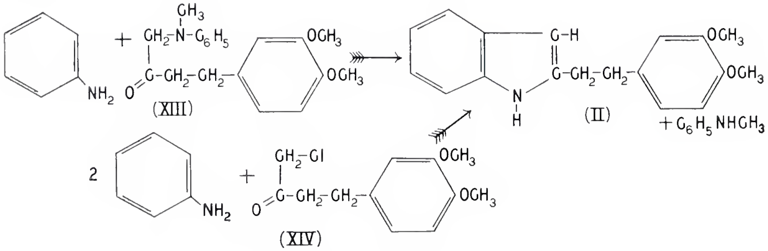
---

[5] Oddo and Sanna, 1921. Gazz. Chim. Ital. (II) 51:334.
[6] Majima, R., 1924. Ber. 57:1449; Hoshino, T., 1933. Ann. 500:35.

Unfortunately Verley's fusion with powdered sodamide is not a pleasant operation. Moreover, it failed completely with the o-toluidide of dimethyl dihydrocaffeic acid (XII) which should have yielded the desired α-homoveratryl indole.[4] We were therefore thrown back upon the method worked out some years ago[4] as the only other attractive alternative for the preparation of such an indole (II). For this preparation,

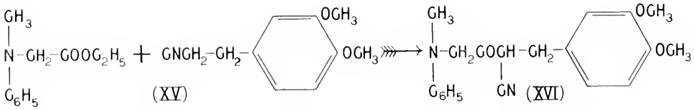

(XII)

however, we needed either the α-amino ketone (XIII) or the α-halogenated analogue (XIV).



(XIII) (II) (XIV)

Accordingly, we prepared the nitrile (XV) and attempted to condense it with N-Methylamino-acetic ester to yield (XVI) as we had already done with benzyl cyanide and veratryl cyanide. This reaction failed to go, indicating that the hydrogen atom alpha to the cyano-grouping is not available for such condensations as is the case with benzyl and veratryl cyanide.


(XV) (XVI)

Hope of securing the amino-ketone (XIII) by this route was therefore abandoned.

Fortunately Nierenstein[7] has suggested a way by which one might hope to secure a chloroketone like (XIV). According to him ω-chloromethyl ketones are formed when acid chlorides are treated with diazomethane. This reaction has since been studied in detail by Arndt[8] has been employed in the synthesis of pilocarpine by Preobrashenski.[9] Actually on treating the acid chloride from dimethyl-dihydro-caffeic acid with diazomethane, the desired chloroketone was obtained in excellent yield, and this chloroketone gave, likewise in excellent yield, the desired α-homoveratryl indole on heating with aniline.

---

[4] Julian and Pikl. Soc. Cit.

[7] Nierenstein, M. et al., 1915. J. Chem. Soc. **107**:1499; ibid **117**:1153 (1920). J. A. C. S. **46**:2554 (1924); ibid **47**:1728 (1925); Ber. **60**:1026 (1927).

[8] Arndt, F. et al., 1928. Ber. **61**:1949.

[9] Preobrashenski, N. A. et al., 1933. Ber. **66**:1187.

In view of the ease with which diazomethane is now cheaply prepared in relatively large quantities in the laboratory,[10] the chloromethyl ketones are readily accessible substances.

These chloroketones constitute the surest and most convenient starting material for preparation of α-substituted indoles.

Experimental Part

Arbusow's "α-Propyl Indole".

This substance was obtained according to the data of Arbusow in the yield stated by him. The crude product gave the "pine-shaving" reaction quite definitely. Accordingly, the picrate was prepared from equimolecular quantities of crude indole and picric acid in methyl alcoholic solution. Recrystallized from methyl alcohol it was obtained in dark red crystals, melting at 153°. On decomposing the pure picrate with alkali and recovering the indole in the usual way, the latter was secured pure; b.p. 159-161°, 14 mm. This product did not give the pine-shaving test.

Reaction of α-Methyl Indolylmagnesium Iodide with Ethyl Iodide.

To a Girgnard solution from 10.9 g. methyl iodide and 2.4 g. magnesium in dry ether, 8.5 g. of α-methyl indole (m.p. 59-60) was added with good cooling. After evolution of methane had ceased, the mixture was heated for one hour on the water bath. The principal portion of the ether was then distilled off, iso-amyl ether was added to replace it, and to the cooled solution thus obtained 15.7 g. of ethyl iodide was added. After the little additional evolution of gas had subsided, the reaction mixture was sealed in a tube and heated for 10 hours in a boiling water bath. Considerable solid separated. The contents of the tube were taken up with water and ether, with addition of a small quantity of acid, and the ethereal solution distilled at 144-148° (9 mm.) giving the violet-red picrate of Arbusow's "α-propyl indole" and therefore identifying the latter as α-methyl-β-ethyl indole.

Verley's α-Propyl Indole.

Prepared according to the directions of Verley, this indole distilled at 160-162°, 15 mm., and on standing in the ice chest solidified; m.p. 32. The picrate, prepared from equimolecular quantities of picric acid and indole in ethereal solution, melted at 149°. In contrast to the picrate of α-methyl-β-ethyl indole, it is a light brick-red. This difference in color between picrates of α-substituted and of α, β-disubstituted indoles we have found for all cases studied. It constitutes a convenient sight method for differentiating between these two classes of indoles. Mixed with the picrate of Arbusow's indole, Verley's α-propyl-β-ethyl indole in exactly the same fashion as α-methyl indole was converted into the α-methyl-β-ethyl derivative. The product distilled at 158-162°, 11 mm. The deep red picrate, made in alcoholic solution and recrystallized from alcohol, melted at 116°. In order to identify it, the phenylhydrazone of di-n-propyl ketone was prepared, an oil which distilled at 162-163°, 11 mm. On fusion with anhydrous zinc chloride according to Fischer, α-propyl-β-ethyl indole was secured, identical with the product secured by action of ethyl iodide on the magnesium derivative of Verley's α-propyl indole. Likewise were the two picrates, m.p. 116°, identical. Thus Verley's product is actually α-propyl indole.

---

[10] Arndt, F., 1935. Organic Syntheses: 15:3.

Preparation of α-Homoveratryl Indole.

After attempts to condense homoveratryl cyanide, prepared according to the method of Baker and Robinson[11] with N-methylanilino-acetic ester, had proved fruitless, the reaction of diazomethane on the acid chloride of dimethyl-dihydro-caffeic acid was studied. This acid chloride was prepared by action of thionyl chloride on the acid and distilled at 150°, 0.8 mm.

To a solution of 10.3 grams of the acid chloride dissolved in 200 c.c. absolute ether was added a diazomethane solution prepared from 30 grams of nitrosomethyl urethane. The solution was allowed to stand for 30 hours, first at low temperature and after twelve hours at room temperature. It was then concentrated at low temperature to about 250 c.c., cooled in a freezing mixture, and swept through with dry hydrogen chloride for about half an hour. After a short time nitrogen evolution began. Allowed to stand for 45 minutes, the solution was neutralized with aqueous bicarbonate, the ethereal solution dried over sodium sulphate and on concentration, beautiful crystals separated but melted on filter paper. The total residue on removal of ether was 10.5 g. Without further purification this crude chloroketone was mixed with 15 grams of aniline and heated at 120° for 20 minutes, then at 180° for 1 hour. The residue after heating was taken up in water and ether and the ethereal solution washed successively with 3% hydrochloric acid and water and vacuum distilled. The fraction boiling at 205-210° (0.1 mm.) was collected, 3.6 g. A small portion of lower boiling material, 150-180°, and which crystallized, was discarded. Recrystallized from methyl alcohol, then from benzene petroleum ether, the 3.6 g. of material gave 2 g. of pure indole, m.p. 126-128°. It gave the pine shaving test.

Anal. Calcd. for $C_{18}H_{19}O_2N$: C, 76.83; H, 6.81
Found: C, 77.07; H, 1.94

---

[11] Baker and Robinson, 1925. J. Chem. Soc. 127:1433.

CONTRIBUTIONS TO THE CHEMISTRY OF TRYPTOPHANE

F. M. Miller[1] with R. E. Lyons, Indiana University

The amino acid, tryptophane, is a protein "building block", indispensable in animal nutrition and is characterized by reactivity and fragility. It is rapidly destroyed by boiling with concentrated mineral acids to give humin substances and by strong alkalies and by certain fecal bacteria to yield indol.

A number of methods have been proposed for the quantitative determination of tryptophane in proteins. In nearly every instance there is prescribed a different, specific way in which the protein hydrolysis is to be carried out. The final result is perhaps quite as dependent upon this factor as upon the method of analysis itself.

Dakin[2], using active pancreas extract as the hydrolyzing agent, isolated and weighed the tryptophane in casein and reported 1.7%. Other methods applied to casein produced results which range from 0.5%, as found by Herzfeld,[3] who digested the protein with pancreatin, to 2.26% as reported by Furth and Nobel.[4] The method of Sanders and May,[5] based upon the estimation of indole produced by the action of fecal bacteria on casein, yielded 1.6%.

The present investigation is concerned with further study of the phenol-hypochlorite color reaction of tryptophane previously reported by the authors[6] and the extension of its application to certain phases of tryptophane chemistry, as follows:

(1) Use of the color test for tryptophane as a means of studying the extent of protein cleavage based upon tryptophane production;

(2) Improvement of the phenol-sodium hypochlorite method for tryptophane estimation by increasing its sensitivity, simplicity, speed, and ease of application, so that it may be applied directly to protein hydrolysates without decolorizing, concentrating, or additional procedures of any kind other than neutralizing and making up to volume;

(3) Use of the improved tryptophane test as a means of studying the resistance of the liberated tryptophane in protein hydrolysates when subjected to the continued action of strong hydrolyzing agents;

(4) Use of the improved test as a means of studying the efficiency of some hydrolyzing agents in the cleavage of tryptophane from casein.

Experimental

The reagents used in this work are the same as those described in the above mentioned paper.

To determine if the phenol-hypochlorite color test is applicable directly to proteins, i.e. without previous hydrolysis, egg albumin "solutions" of various concentrations were subjected to the test with results as follows:

---

[1] Condensed form of a thesis submitted in partial fulfillment of requirements for the degree Ph.D.

[2] Dakin, H. D., 1918. Biochem. J. **12**:290.

[3] Herzfeld, E., 1913. Biochem. Z. **56**:258.

[4] Furth, O. and Nobel, E., 1920. Biochem. Z. **109**:103.

[5] Sanders, J. A. and May. C. E., 1912-3. Biochem. Bull. **2**:373.

[6] Miller, F. M. and Lyons, R. E., 1934. Proc. Ind. Acad. Sci. **43**:132.

	NaOCl .26% Na_2O .009%
Tryptophane	rose
M/100 egg albumin	no color
M/200 egg albumin	no color
More dilute egg albumin	blue-green
Very dilute egg albumin	blue-green

The rose color reaction of tryptophane is not obtained when the test is applied to the unhydrolyzed protein molecule, but the blue-green color characteristic of glycine is given by egg albumin under the described conditions.

Numerous attempts were made to execute the necessary hydrolysis of protein in such a manner as to yield a colorless hydrolysate suitable for the tryptophane test. The hydrolysates of casein produced by refluxing with 10, 15 and 20% hydrochloric and sulphuric acids were, without exception, highly colored. Hydrolysates, when neutralized or when freed from excess of acid by distillation under reduced pressure, could not be obtained sufficiently color-free by subjecting casein or egg albumin to the action of formic or acetic acids in 10% to 50% concentration in an autoclave at 150° C., as recommended by Zelinsky and Ssadikow[7].

It was also our observation that pure tryptophane heated for 7 hours with 25% acetic acid in the autoclave at 150° C. yields some indole as evidenced by odor, positive Konton's test, and positive p-dimethyl amino benzaldehyde test.

The baryta hydrolysis of casein was undertaken in sealed flasks at 150° C. for 18-22 hours in an autoclave with the idea that both tryptophane and any indole, resulting from continued action of the agents of alkaline proteolysis upon tryptophane, could be determined in the hydrolysate after removal of the barium by precipitation with sulphuric acid.

The slightly acid filtrates from barium sulphate were colored or acquired objectionable color after a few hours. Indole determinations by the Bergeim method[8] in the distillates from seven hydrolysates of casein showed that the amount of indole produced under these conditions is but .004% to .008%.

In the attempts to apply the phenol-sodium hypochlorite color test as a quantitative procedure to protein hydrolysates the unavoidable dark color and the difficulty of obtaining a perfectly neutral solution proved to be serious obstacles, and the necessity for application of the color test to highly acid or highly alkaline solutions was apparent.

As a preliminary, a mixture of 2 m.l. M/100 aqueous tryptophane solution, 8 drops 5% equeous phenol and 2 m.l. 0.15% sodium hypochlorite solution was prepared in each of five test tubes. Of these, two are made alkaline and two acid with results as follow:

6 drops .4N. NaOH	3 drops .4N. NaOH	Blank	3 drops .4N. HCl	6 drops .4N. HCl
No Color	No Color	Pink	Deep Red	Deep Red

---

[7] A. C. S. Monograph 48:98. 1929.

[8] Hawk and Bergeim, Phys. Chem. (10th Ed.) p. 371. 1931.

Repetition of the above without the presence of phenol showed that the latter was not essential for the production of the red color with tryptophane in acid medium. It follows, in the light of previous work, that phenol probably serves only in creating a slightly acid medium and does not enter into the molecule of the tryptophane color complex.

To determine whether or not the accentuation of the color in the test solution due to the addition of mineral acid was specifically characteristic for tryptophane, the test was applied to 1/50 and 1/100 M. solutions of twelve amino acids and to indole under the same conditions, i. e. 2 m.l. amino acid solution, 2 m.l. 0.15% sodium hypochlorite and varying amounts of 0.4N. acids.

	M/50 Blank	M/50 3 dr. HCl	M/50 8 dr. HCl	M/100 3 dr. HCl	M/100 8 dr. HCl	M/100 4 dr. H_2SO_4
Glycine						
Glutamic acid						
Aspartic acid						
p-NH_2 phenylacetic	brown	brown	brown	brown	brown	brown
Alanine						
Proline						
a-amino caproic						
Histidine.2HCl						
Iso-leucine						
Phenylalanine						
Leucine						
Tryptophane	pink	red	red	red	red	red
Indole	turb.	gr-yl	gr-yl	gr-br	gr-br	gr-trub

The intense deep red color is specific for tryptophane. The faint pink color yielded by indole changes quickly to greenish yellow.

The effect of the strength of the hypochlorite solution upon the color formation was determined on 1 m.l. portions of 1/100 M. tryptophane.

Drops	“A”	“B”	“C”	‘ D”
.4N HCl	0.31% NaOCl	0.15% NaOCl	0.10% NaOCl	0.08% NaOCl
1	dark	very good	very good	fair
4	dark	very good	very good	fair
7	dark	very good	very good	fair

In series “A” the colored compound precipitated. Series “B” and “C” were brilliant cherry red in color and showed no precipitation of the pigment.

About equally satisfactory color was obtained when 1 to 10 drops of 0.4N. hydrochloric acid were used; more induced fading of the color.

Satisfactory check results were obtained only when the hydrochloric acid was added last. Under those conditions the cherry red color formed at once and exhibited marked stability for weeks.

Sensitivity of the Improved Test.—Two m.l. portions of very dilute tryptophane solutions were mixed with 2 m.l. of 0.1% sodium hypochlorite and 1 to 2 drops of 0.4N. hydrochloric acid added with results as follow:

M/50 tryptophane: Very intense red color. Too intense for quantitative comparisons; M/1250 showed good red color; M/3750 good pink; M/6250 nice pink color suitable for quantitative work. This amounts to 0.0000313 gr. tryptophane per ml. or one part in 31900 parts. M/12500 immediately distinct pink sufficient for indentification test. This dilution expresses about the lower limit of the sensitivity and corresponds to one part in 63000 parts of solution.

Solution and Extraction of the Reaction Color.—A number of solvents, benzene, toluene, chloroform, ether, n-butyl alcohol and iso-amyl alcohol, were tried with the idea of extracting the pink or red color which is formed by the action of sodium hypochlorite on tryptophane in an acid medium. Iso-amyl alcohol only was found satisfactory. By it the pink color is extracted quantitatively from the reaction mixture. The alcoholic solution of the pigment may be kept unchanged for weeks.

Advantages of the Reaction Color Extraction.—1. The iso-amyl alcohol color extraction enables the analyst to make quantitative determinations on hydrolysates otherwise too highly colored for successful colorimetric work.

2. It enhances the sensitivity of the test; a 10 ml. portion of amyl alcohol will, for example, extract all of the color from a volume of 50 ml. of reaction mixture which would in itself be too weak in color for direct colorimetric work. This increases the normal sensitivity of the test many times.

3. The test becomes very flexible. Either standard or unknown color extract may be diluted with additional alcohol for purposes of approximating color intensities. This does away with the need of having several standards, since only one is needed.

4. It does away with the necessity of keeping constant volumes in the reaction mixtures as compared to standards, involving quantities of reagents.

5. Since the amount of color extracted, and not the quantity of hypochlorite absorbed, is a measure of the tryptophane value, it follows that the presence of other substances which also absorb sodium hypochlorite does not interfere with the accuracy of the test.

Application of the Test to Protein Hydrolysates.—1. Successful quantitative application of the improved test to an unknown requires that the correct amount of sodium hypochlorite should be added to produce the maximum intensity of color. To determine this the following scheme has been adopted:

1	2	3	4	5	6	7
5.0 ml. sol. 0.2 ml. NaOCl 10 drops HCl no color	5.0 ml. sol. 0.4 ml. NaOCl 5 drops HCl weak color	5 ml. sol. 0.6 ml. NaOCl 10 drops HCl good color	5.0 ml. sol. 0.8 ml. NaOCl 5 drops HCl good color	5.0 ml. sol. 1.0 ml. NaOCl 10 drops HCl good color	5.0 ml. sol. 1.4 ml. NaOCl 10 drops HCl good color	5.0 ml. sol. 1.8 ml. NaOCl 10 drops HCl dark color

The conditions as described for No. 3 were found the best for color development.

2. The hydrochloric acid should be the last reagent, and the entire quantity used should be introduced at one time. A fast rate of fading of color is indicative of excessive acidity.

3. The reaction mixture is extracted with iso-amyl alcohol as soon as possible after the addition of the hydrochloric acid. Color comparisons of the clear extracts are then made by use of a Duboscq colorimeter against a standard prepared from pure tryptophane. A 2 ml. portion containing 0.00015 gr. per ml. is placed in a test tube containing about 3 ml. of water. To this is added 0.1 ml. of 0.5% sodium hypochlorite solution and one or two drops of 0.4N. hydrochloric acid. The amyl alcohol extraction may be made at any time within about ten minutes after the last reagent is added.

Effect of Strong Hydrolyzing Agents.—It is our observation that a sample of casein which had been hydrolyzed with 15% sulphuric acid for a period of 30 hours at reflux temperature showed no tryptophane present. If the same conditions are maintained except that the heating period is reduced to 15 hours, there is obtained a test which may indicate a trace of tryptophane present. If the heating period is cut to five hours and the same test is applied, a good amount of tryptophane is indicated by the color. This shows that the long heating period and the continued action of the sulphuric acid are destroying the tryptophane previously liberated. One is not surprised to find, in view of the above observations, that a casein sample when refluxed with 20% hydrochloric acid for 25 hours should fail also to give a positive test.

The hydrolysate obtained from the use of a strong solution of barium hydroxide upon casein at 150° C. for 30 hours and neutralized with hydrochloric acid contained 0.44% tryptophane. If the heating period is cut to 20 hours and to 10 hours, values of 0.48% and 0.63% respectively were obtained.

The following table shows the results obtained when 2.5 gr. portions of casein (technical) were heated with 100 gr. each of the indicated barium hydroxide solution.

$Ba(OH)_2$	10 Hours	20 Hours	30 Hours
10%	0.3%	0.4%	0.7%
20%	0.6%	0.8%	0.8%
30%	0.6%	0.7%	0.9%
40%	0.7%	0.9%	0.7%
50%	1.0%	1.0%	0.7%

An aliquot part of a solution of pure tryptophane refluxed for 30 minutes with 20% barium hydroxide gave but 84% of the amount present in the part not treated with barium hydroxide. Since the strong mineral acids and alkalies possess as casein-hydrolyzing agents the ability to split off tryptophane and also to decompose this amino acid, they are not satisfactory. The tryptophane value so obtained is merely the difference between the amount released and the amount decomposed.

Conclusions

1. The phenol-sodium hypochlorite color test for tryptophane, when applied to the usually discolored protein hydrolysates, was found unsatisfactory.

2. In ordinary casein hydrolysis very little tryptophane is converted to indole. The addition of some inorganic salts aids slightly in indole production. Pure tryptophane is unable to withstand the continued action of barium hydroxide and yields considerable indole.

3. A very specific, senstive, speedy, and reliable color test for the qualitative and quantitative determination of tryptophane, resulting from the addition of a small amount of sodium hypochlorite previous to slight acidification, was developed. The test is dependent upon a cherry red color which develops immediately, is very stable, and is quantitatively extractable with iso-amyl alcohol; it is applicable to protein hydrolysates, regardless of discoloration, and is so flexible as to require only one tryptophane solution as a standard over a wide range of concentrations of unknown samples.

4. The continued action of strong sulphuric and hydrochloric acids as hydrolyzing agents has been found to be so destructive to the tryptophane contained in protein hydrolysates that not a trace could be detected.

5. Low concentrations of barium hydroxide as hydrolyzing agents are slow in splitting tryptophane from the casein molecule, while higher are more effective and also more destructive to the tryptophane previously set free.

A RAPID PROCEDURE FOR THE DuCLAUX ANALYSIS OF DILUTE MIXTURES OF FORMIC AND ACETIC ACIDS

Fred O. Gibson and W. E. Bradt, State College of Washington

Introduction

Several methods (1, 2, 3, 4) which require considerable time in their operation have been devised for the analysis of mixtures of formic and acetic acids. It was decided to develop a more rapid modification of the DuClaux (5) method for the determination of volatile acids in sulphuric

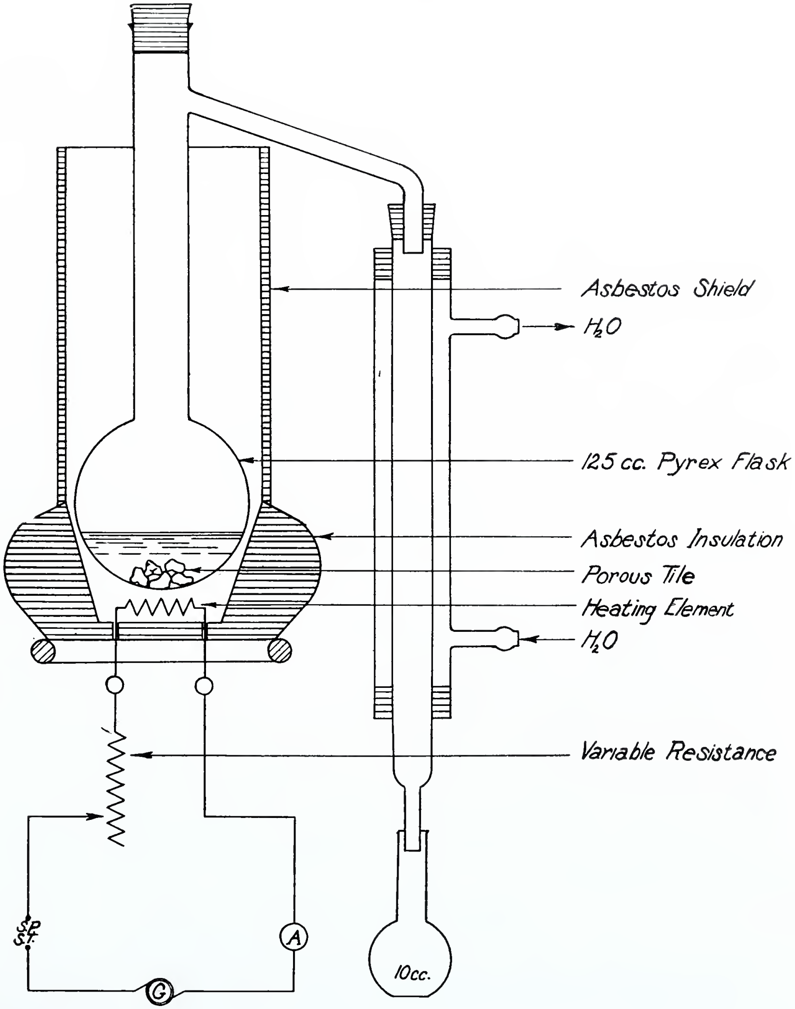


Fig. 1.

acid solutions resulting from the electrochemical oxidation of acetone. This procedure depends upon the regularity with which the two volatile acids distill, whether alone or in the presence of each other.

Experimental Procedure

Apparatus.—The flask for the acid distillation consisted of a 125 c.c. Pyrex distilling flask with the delivery tube bent to fit into the upper end of a twelve-inch vertical Liebig condenser. The lower end of the condenser was drawn out to fit well into a 10 c.c. volumetric flask, which served as a receiver of the distillate. Two such flasks were needed. The distilling flask was partially insulated by means of a cylindrical asbestos shield extending up to the delivery tube. See Figure 1.

The heating element consisted of twenty feet of B. and S. No. 22 Nichrome resistance wire made into five series coils well insulated with asbestos. A variable resistance of thirty feet of the same size Nichrome wire was placed in series with the heater element so that the rate of distillation could be controlled. The variable resistance was adjusted so that the rate of distillation was fairly rapid.

Procedure.—The solution to be analyzed was made up to 100 c.c. with carbon dioxide-free (6) 1.5 sulphuric acid. Ten cubic centimeters of this solution was diluted to 250 c.c., of which 5 c.c. was further diluted to 25 c.c. and used for the determination of formic and acetic acids. This solution was placed in the apparatus and distilled. The distillation was allowed to proceed until a 10 c.c. fraction had been collected and removed, and a second 10 c.c. fraction had been collected. Bumping was prevented by the addition of five small pieces of porous tile. The same pieces of tile were used throughout all subsequent determinations.

Each of the two 10 c.c. fractions was washed into a flask with carbon dioxide-free water and titrated[1] with 0.01N barium hydroxide solution (7), using phenol red (8), as the indicator. The titration values of each fraction were then corrected by a blank titration on the chemicals used, and the amounts of formic and acetic acids present in each fraction were calculated.

Standardization of Apparatus.—DuClaux showed that aqueous solutions of either formic or acetic acid distill in the presence of each other, exactly as if only one acid were present. The apparatus described above was standardized by the distillation, collection, and titration of the first and second 10 c.c. aliquots of separate sulphuric acid[2] solutions of formic and of acetic acid. From the data obtained and from the original concentrations, a *titration constant* for each acid was calculated. This was expressed in terms of cubic centimeters of 0.01N barium hydroxide per milligram of sample in each of the two 10 c.c. fractions. This permitted the calculation of the amount of formic and of acetic acids present in a mixed sample. From these data, presented in Table I, the following facts were obtained:

$$a = 0.239 \text{ Ac} + 0.202 \text{ Fo}$$
$$b = 0.294 \text{ Ac} + 0.295 \text{ Fo}$$

---

[1] The buret was graduated in intervals of 0.05 c.c.

[2] This was prepared to contain the same concentration of sulphuric acid as the solution to be analyzed.

Here *a* and *b* are the titration values of the first and second 10 c.c. fractions, respectively. *Ac* and *Fo* represent the quantities of acetic and formic acids, expressed as milligrams, present in the sample. If the two above equations are solved simultaneously for *Ac* and *Fo* the following equations are obtained:

$$Ac = \frac{1.46\ a - b}{.55} \qquad Fo = \frac{a - 239\ Ac}{.202}$$

By substituting the titration values obtained, the amount of formic and acetic acids present in a mixed sample may be determined.

TABLE I

Standardization of Apparatus

Sample in Milligrams	H_2SO_4 Content in cc.[1]	Observed Titration in cc. of 0.01*N* $Ba(OH)_2$ Corrected for Blank		Titration Constant per mg. of Sample	
		1st Fraction	2nd Fraction	1st Fraction	2nd Fraction
			ACETIC ACID		
5	5	1.195	1.470	0.239	0.294
10	5	2.388	2.950	0.239	0.295
15	5	3.590	4.400	0.239	0.293
20	5	4.745	5.980	0.239	0.294
Average				0.239	0.294
10	10	2.250	2.600	0.225	0.260
			FORMIC ACID		
5	5	1.010	1.470	0.202	0.295
10	5	2.050	2.950	0.205	0.295
15	5	3.000	4.450	0.200	0.296
20	5	4.040	5.880	0.202	0.294
Average				0.202	0.295
10	10	1.900	2.700	0.190	0.270

[1] 10 c.c. of 1:4 H_2SO_4 diluted to 250 c.c.

Analysis of Known Solutions.—In Table II are shown the results of analyses of known samples of mixtures of formic and acetic acids, both in the absence and presence of acetone. The table shows the titration values of each fraction, also the amount of acetic and formic acids present in the sample and the amount of each found.

Discussion.—A change in the rate of distillation, the size of the distillation flask, and the concentration of the sulphuric acid in the liquid to be distilled introduce variations in the titration constants, making the values tabulated in this article hold only for the apparatus for which they were determined. Any substance in the liquid to be distilled which, upon distillation, decomposes to form volatile acids or carbon dioxide will cause an erroneous interpretation of the results.

Exactly the same amount of indicator solution must be added for each determination. To prevent small drops of the distillate from adhering to the sides of the condenser, the apparatus must be thoroughly cleaned before each determination.

TABLE II

Analysis of Known Solutions

Sample in Milligrams	*a*—1st Fraction cc. 0.01*N* $Ba(OH)_2$	*b*—2nd Fraction cc. 0.01*N* $Ba(OH)_2$	Found Acetic Milligrams	Found Formic Milligrams	Acetone Present Milligrams
5 Acetic 10 Formic	3.21	4.41	4.9	10.1	None
10 Acetic 10 Formic	4.41	5.89	9.8	10.0	None
10 Acetic 5 Formic	3.40	4.42	9.9	5.1	None
2 Acetic 5 Formic	1.49	2.08	2.0	4.9	None
15 Acetic 5 Formic	4.59	5.88	14.9	5.1	None
5 Acetic 15 Formic	4.23	5.89	5.1	14.9	None
5 Acetic 10 Formic	3.21	4.41	4.9	10.1	25
10 Acetic 10 Formic	4.42	5.89	9.9	10.0	25
10 Acetic 5 Formic	3.40	4.42	9.9	5.1	25

Volumes other than 25 c.c. of the liquid to be distilled were used with success except for the fact that larger volumes required more than the average time. The procedure, as outlined, permits a complete analysis in twenty minutes. An examination of the data in Table II shows a reasonable check between the amounts of acetic and formic acids present and the amounts found by analysis. This adaptation of the DuClaux method was successfully used for the analysis of anolytes obtained in the electrochemical oxidation of aqueous acetone-sulphuric acid solutions.

Literature Cited

1. Craig, 1931. Bur. of Stand. J. Res. **6**:169-82.
2. Scott, 1925. Standard methods of chemical analysis, p. 1545, 4th ed.
3. Nelson and Beck, 1918. J. Am. Chem. Soc. **40**:1001-05.
4. Held and Zeileis, 1913. Ber., **46**:1171-77.
5. Blyth, 1888, 1909. Foods: Their composition and analysis. 3rd ed., pp. 487-496 and 6th ed., pp. 449-450.
6. Findlay, 1923. Practical physical chemistry. 4th ed., p. 144.
7. Ibid, p. 145.
8. Hall, 1930. Textbook of quantitative analysis. p. 42.

THE EFFECT OF SODIUM ORTHO PHENYL PHENATE ON VISCOSITY, JELLY STRENGTH, AND ADHESIVE STRENGTH OF GLUE[1]

I. F. Fleischer and R. J. Hartman, Indiana University

The use of sodium ortho phenyl phenate as a glue preservative was introduced about four years ago by the Dow Chemical Company, Midland, Michigan. In this investigation the effect of the addition of various amounts of sodium ortho phenyl phenate to glues on viscosity, jelly strength, and adhesive strength was studied.

Experimental

Materials.—Two different grades of animal glue were furnished by the Conrad-Kammerer Glue Company, Inc., New Albany, Indiana. Their method of preparing the glues in their plant was as follows: The raw material was first soaked in a concentrated solution of lime, washed free of the lime, treated with sulphurous acid, washed again, and then subjected to hot water, which dissolved all the gelatinous substance. Excess water was evaporated from the solution of glue and at this point portions were withdrawn, jelled, dried and pulverized, samples of glue being thus obtained without having had any preservative added.

The sodium ortho phenyl phenate was obtained from the Dow Chemical Company, Midland, Michigan. In their bulletin "Glue Preservation" (Special Development Bull. 14, Dow Chemical Company. 1931) the following chemical and physical properties of sodium ortho phenyl phenate are given: chemical formula—$NaCO_6H_4C_6H_5 .3H_2O$, melting point—78° C., molecular weight—246, color—white, form—needle crystals, solubility in water—40% at room temperature.

In this bulletin it is cited that this compound is a glue preservative and that it increases the tensile strength as measured by the "maple block test".

Apparatus and Method of Procedure.—A series of samples was prepared in duplicate by accurately weighing fifteen grams of the same grade of commercial dry glue. To each of these samples was added varying percentages of sodium ortho phenyl phenate by dry weight of glue and 105 c.c. of distilled water at approximately 15° C. The samples were permitted to soak over night at a temperature of approximately 15° C. and then placed in a melting bath and brought to 62° C. The time required to bring the samples up to this temperature did not exceed 15 minutes. Having attained the required temperature there was no delay in transferring the glue solution to the viscosimeter. The viscosities were determined at 60° C.

The same samples were allowed to jell at 10° C. for 17 hours. The determination of the jelly strength of the samples was made with a Bloom gelometer (J. Ind. Eng. Chem., analytical Ed. 2:348. 1930), adjusted to give a 4 mm. depression. Results are expressed in the nearest whole gram required to produce the 3 mm. depression. The tests reported were determined at the same time and under the same conditions.

---

[1] The tensile strengths of the glues were determined at Purdue University, under the direction of Professors Hatt and Hollister.

Results.—Table I shows the effect of the addition of varying percentages by dry weight of sodium ortho phenyl phenate on viscosity and jelly strength of a high grade glue.

TABLE I

pH, Viscosity, and Jelly Strength as Affected by Sodium Ortho Phenyl Phenate

Sample No.	% Sodium Ortho Phenyl Phenate by Dry Weight of Glue	pH (Colorimetric)	Viscosity in Millipoise	Jelly Strength (grams)
1	.0	6.40	78.5	262
2	.2	6.55	79.0	267
3	.4	6.60	79.5	257
4	.5	6.75	80.0	260
5	.8	6.80	78.5	256
6	1.0	6.95	77.5	252

None of the samples in Table I contained zinc sulphate.

It was found that the addition of sodium ortho phenyl phenate did not noticeably increase the foam of the glue solutions.

Increasing the percentage of sodium ortho phenyl phenate caused the glue solutions which were acid originally to become less acid, as would be expected. As the percentage of sodium ortho phenyl phenate was increased to 1% the glue solutions became nearly neutral, as indicated in Table I. Glue solutions containing 3% or more (not included in the above table) were very slightly alkaline.

Figure 1 shows the curve obtained by plotting the viscosity against the percentage of sodium ortho phenyl phenate by dry weight of glue.

In order to determine the effect of varying amounts of sodium ortho phenyl phenate on the adhesive strength of low and high grade glues, 33⅓% glue solutions were prepared. To these were added varying percentages of sodium ortho phenyl phenate by dry weight of glue. The mixtures were heated on a water bath until homogeneity was reached. This required approximately one and one-half hours.

Air dried maple blocks (2"x2"x11"), dried in an electric oven at 100° F. for a period of 48 hours before each test, were used in determining the adhesive strengths. A film of this hot glue was applied to the ends of two maple blocks. The blocks were then mounted in an upright position and pressed together firmly with the hands. The specimens were allowed to dry in this position at room temperature for a period of

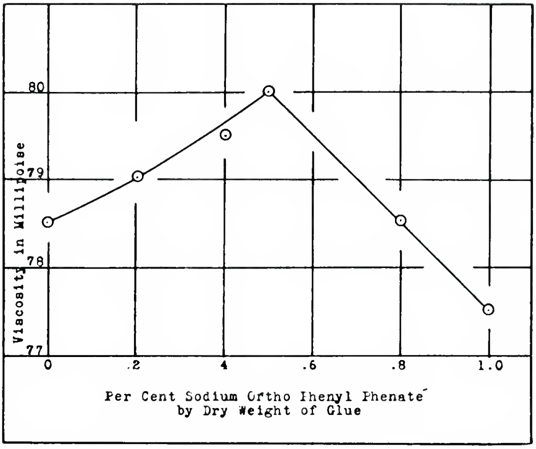


FIG. 1

ninety-six hours. At the end of this drying period, the strength tests were conducted. In each case three specimens were made for each glue. This was considered necessary since the fiber structure of the blocks varies considerably. After testing the specimens, a thin section of the glued ends of each block was cut off in a miter box with a saw and the same blocks used in the next two duplicate tests of the same glue sample.

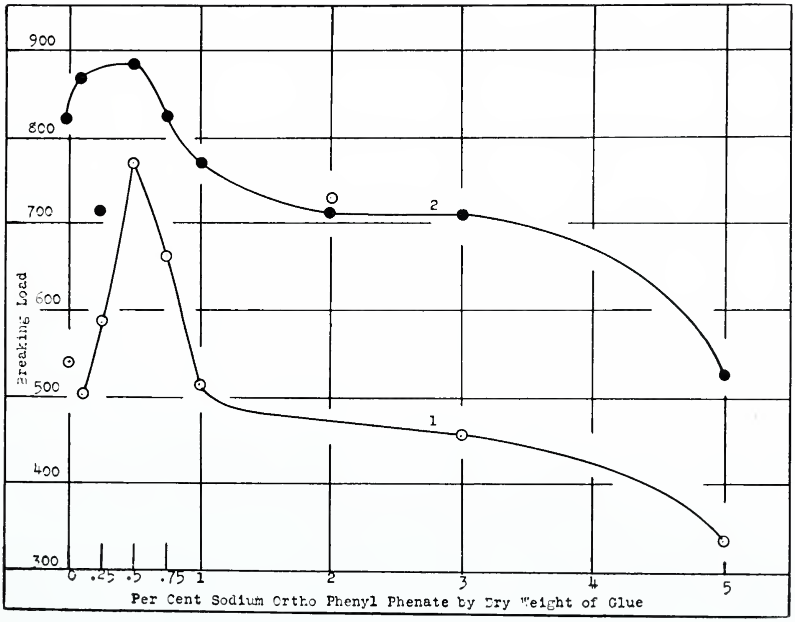


FIG. 2.

TABLE II

Adhesive Strength of Glue as Affected by Sodium Ortho Phenyl Phenate

% Sodium Ortho Phenyl Phenate by Dry Weight	Low Grade Glue		High Grade Glue	
	Specimen Number	Breaking Load (Lbs.)	Specimen Number	Breaking Load (Lbs.)
0.00	1a	605	10a	870
0.00	1b	585	10b	800
0.00	1c	425	10c	790
		Av. 538		Av. 820
0.10	2a	255	11a	935
0.10	2b	540	11b	885
0.10	2c	460	11c	780
		Av.(2b,2c) 500		Av. 866
0.25	3a	550	12a	780
0.25	3b	765	12b	720
0.25	3c	435	12c	640
		Av. 583		Av. 713
0.50	4a	610	13a	900
0.50	4b	795	13b	900
0.50	4c	900	13c	850
		Av. 768		Av. 883
0.75	5a	525	14a	730
0.75	5b	610	14b	845
0.75	5c	850	14c	820
		Av. 662		Av. 798
1.00	6a	580	15a	895
1.00	6b	505	15b	745
1.00	6c	450	15c	665
		Av. 512		Av. 768
2.00	7a	685	16a	650
2.00	7b	785	16b	645
2.00	7c	1055	16c	840
		Av.(7a,7b) 735		Av. 712
3.00	8a	430	17a	835
3.00	8b	370	17b	740
3.00	8c	560	17c	685
		Av. 453		Av.(17b,17b) 71
5.00	9a	310	18a	530
5.00	9b	320	18b	550
5.00	9c	375	18c	495
		Av. 335		Av. 525

All strength tests were conducted in a standard (30,000 lbs.) Universal testing machine, sensitive to 5 pounds.

The test specimens were mounted horizontally in the machine on standard knife-edge bearings, spaced 18 inches apart. Suitable roller bearings and plates were provided between the knife-edges and the wood test blocks. The loads were applied at mid span through the medium of a wood block and a curved plate.

Figure 2 shows the graphs obtained by plotting the data in Table II. Curve 1 is plotted from the data obtained with the low grade glue and curve 2 from the data obtained with the high grade glue. It is evident from Figure 1 that additions of sodium ortho phenyl phenate up to 0.5% by dry weight of glue increase the adhesive strength of the glues, the low grade glue being aided more than the high grade glue.

Discussion and Conclusion

From Table I it is noted that the addition of sodium ortho phenyl phenate increases the pH. This might account in part for the corresponding changes in the various physical properties of glue. It is interesting to find that this compound claimed by the Dow Company to be a preservative seems to improve the physical properties of a glue as well.

The addition of 0.25% to 0.50% sodium ortho phenyl phenate to glue tends to increase the jelly strength and to lessen acidity. It prevents deterioration, does not cause increased foam, and increases the adhesive strength as herein measured.

A REVIEW OF A CENTURY OF CHEMICAL EDUCATION IN INDIANA

LOUIS AGASSIZ TEST and FRED J. ALLEN, Purdue University

In a recent article on the Extent of Chemical Education, Victor H. Noll (1) makes the statement that the first professorship of chemistry in America was established at Kings College in 1767. The next institution to offer chemistry was the University of Pennsylvania in 1769.

Indiana at this time was mostly an unsettled wilderness, and it is not strange that we find no chemical instruction in the state until more than 50 years later.

At the founding of the Indiana Academy of Science in Indianapolis, December 29, 1885, we find a record of a paper presented by Robert B. Warder, then professor of chemistry at Purdue University, entitled "Chemical Work in Indiana" (2). Thirty-one years later, in Indiana's centennial year, Dr. J. H. Ransom, also of Purdue University, presented a paper before the Indiana Section of the American Chemical Society (3) in which he traced the growth of chemistry in Indiana from the beginning of the state to the end of the first hundred years. These two papers were designed to give insight into the growth and development of the science of chemistry in Indiana and to serve as a reference for those interested in the history of the state.

In order to complete this record and bring it up to date, we are now, in 1935, fifty years after the founding of the Academy, presenting a brief sketch of the past hundred years of chemical education in Indiana colleges. The main purpose of this sketch is to present a statistical record which will serve as a reference to show the rapid advancement in the past twenty years.

The history of chemistry in Indiana, as well as all science in the state, probably began when the famous "boat load of knowledge" ascended the Wabash River, and landed at New Harmony early in 1826. As this colony boasted a number of eminent geologists, interested in the composition of minerals and soils, the early development of chemistry in the state was closely related to that of geology. Indeed, much important chemical work was later carried on by some of our state geologists. At this early date we find most of the scientists interested in natural science or natural philosophy in general rather than in chemistry in particular.

Soon after the coming of these scientists to New Harmony, colleges began to be established in Indiana. Hanover College opened its doors to students in 1827, and in 1828 the State Seminary, founded at Bloomington in 1820, was changed in rank to Indiana College. Wabash College was founded in 1832, and instruction began late in the following year. Other colleges soon followed.

The earliest record of chemistry in the curriculum of an Indiana college is 1829, when John H. Harney was appointed to the chair of mathematics, natural and mechanical philosophy, and chemistry at Indiana College. There seems to be no record of what courses were taught (4).

Hanover College mentions chemistry in the list of courses in 1832, and in 1835 one semester of chemistry was required for graduation. Chemistry was a senior subject until 1861. It was not until 1883 that the course here was extended to a whole year, at which time analytical chemistry was added. Two years of chemistry was first offered in 1888.

Chemistry is first mentioned at Wabash College in 1836 when, according to a minute of the Board of Trustees, the appointment of Professor E. O. Hovey was "changed from Rhetoric to Chemistry and Natural Science" (5). At the same institution in 1856 a donation from Chauncy Rose founded the Rose Professorship of Chemistry.

At DePauw University chemistry was taught from 1839 to 1840 by the Reverend Mathew Simpson, President of the University, but no mention is made of the courses taught or the time devoted to the subject. He was followed by Professor W. C. Larrabee, who in turn was followed by Professor C. G. Downey, in 1843.

At Butler University we find the first reference to chemistry in 1858 when R. T. Brown, A.M., M.D., was made professor of Natural Science, Chemistry, Natural Philosophy, Physiology, Botany, Meteorology, Zoology, and Geology.

At Earlham College in 1858 chemistry is listed as one of the subjects taught by Professor Joseph Moore. Whether given at an earlier date, there is no record. There is a tradition at Earlham College that the first course in laboratory chemistry to be offered in the state was given there, and for many years the catalogue carried this statement: "In a room adjoining the present quarters of the Christian Association in Earlham Hall, the first chemistry laboratory in Indiana for the use of college students was located." The catalogue also states in 1864 that second-year chemistry included work in the laboratory. In 1867 a limited course in quantitative analysis was added. In this year Erastus Test was in charge of the chemistry at Earlham College.

In 1836 at Indiana University a building was completed to "furnish additional recitation rooms, library and chemical laboratory". There is no record of when the laboratory was installed (4).

In these early years, courses in chemistry rarely extended over more than a year and often only a semester was offered, usually in the senior year only. Frequently one term was devoted to inorganic and one to organic chemistry. Thus, there was little or no opportunity to specialize. Analytical chemistry could not be given until laboratories were available. These were first introduced about 1865 to 1870, and with this equipment limited courses in qualitative and quantitative analysis could be given. Frequently a term of qualitative analysis was added to the course and sometimes a second term of quantitative analysis when equipment could be secured.

Not until about 1900 did the general application of physics to chemical problems assume importance, and the so-called subject of physical chemistry begin to be developed. It was only after this time that we find courses in theoretical and physical chemistry generally offered. Such courses gave additional impetus to advanced work, and graduate courses increased. Indiana University gave its first master's degree in chemistry in 1890, to R. E. Lyons, now head of its chemistry department, and Purdue University gave its first master's degree in chemistry in the same year, though it had granted the advanced degree of Analytical Chemist as early as 1878 (6). Rose Polytechnic Institute began instruction in 1883 and graduated the first chemical engineer in 1894. The first graduate in chemical engineering at Purdue University was granted his degree in 1909—eighty-five were graduated with this degree in 1934.

The development of laboratories for instruction and research was slow. In the early days chemistry was usually one of several sciences to be taught by a single professor, and little space or equipment was devoted to it alone. Generally it was housed in a building or department with other sciences. At Purdue University, until 1886 or 1887, chemistry shared the first small building to be erected for instructional purposes on the campus along with art, physics, pharmacy, and all the engineering courses. This building, with additions, was later occupied by the Pharmacy School alone and finally outgrown by it some years ago. It was not until 1907 that the first building designed entirely for chemistry was completed at Purdue University (7).

Wylie Hall, completed at Indiana University in 1884, had one floor devoted entirely to chemistry.

The first full-time professorship in one science at Indiana University, and probably the first in the state, was established in 1874, when Professor T. C. VanNüys was appointed to give instruction in chemistry. Trained in German universities and bringing the European ideals of chemical education to Indiana, his coming marks the beginnings of the real development of chemistry at Indiana University and probably in the state.

About the time at which Professor VanNüys went to Indiana University, Purdue University opened, and Harvey W. Wiley was called to have charge of the chemistry. He immediately set about organizing a chemistry course covering four full years of chemistry. All chemistry beyond the first term was elective, and in the advanced courses laboratory practice was especially stressed. When Professor Wiley left Purdue in 1883 to become chief chemist for the United States Department of Agriculture, the school of chemistry was discontinued, and less chemistry was offered for a number of years. It was not until 1892 that chemistry was again offered before the junior year.

There are a few men whose names should be especially mentioned as having very largely influenced chemical education in Indiana in the closing years of the last century:

T. C. VanNüys, Professor of Chemistry at Indiana University from 1874 to 1895, and first full-time professor of chemistry in that institution;

Harvey W. Wiley, first professor of chemistry at Purdue University and state chemist 1874 to 1883; later internationally known for his work as chief chemist with the United States Department of Agriculture;

Robert B. Warder, who followed Professor Wiley at Purdue University, leaving a few years later to have charge of chemistry at Howard University;

J. U. Nef, Professor of Chemistry at Purdue University 1887 to 1889, and later for many years head of the department of chemistry at the University of Chicago;

W. A. Noyes, Professor of Chemistry at Rose Polytechnic Institute from 1886 to 1903; later chemist in the Bureau of Standards and head of the chemistry department of the University of Illinois 1907 to 1926, and since then Professor Emeritus;

Alexander Smith, Professor of Chemistry at Wabash College 1890 to 1894; Professor of Chemistry at the University of Chicago 1894 to 1911, and head of the department of chemistry Columbia University 1911 to 1919;

W. E. Stone, head of the department of chemistry, Purdue University 1889 to 1900; President of Purdue University 1900 to 1921.

These were small beginnings, but from them chemistry has made a steady and rapid growth until today there are three colleges in the state with laboratories each of which will accommodate approximately 1,000 students, and one, at least, can accommodate 2,500. Additions to this largest laboratory are already planned.

Twenty-one Indiana colleges answered a questionnaire sent out relative to the number of students at present in the chemistry courses. A summary of these answers shows 3,386 students enrolled this year in the beginning courses. In 1935 there were 312 students graduated with majors in chemistry or chemical engineering, and 150 were doing graduate work in chemistry. A total of 29 master's degrees and 15 doctor's degrees were granted during the year. Only 4 of 21 colleges reported that they have regular graduate work in chemistry. In the chemistry departments of these 21 colleges there were 49 professors, 16 instructors, and a large number of assistants, most of the latter being graduate students.

The situation as to chemistry courses given in the various colleges and universities of Indiana can, perhaps, best be shown by tables, and several such tables have been prepared (Tables I and II). Only a summary of these will be given at this time.

There are at present at least twenty-three schools beyond the high school level giving work in chemistry. Allowing for one or two minor exceptions, all the colleges and universities present courses in general chemistry. About one-half of them offer courses in physiological and biological chemistry, and more than half offer courses in methods of teaching chemistry.

It might be noted in this latter connection that there is a very noticeable trend toward checking up on the sort of teaching and examining being done. Emphasis is being directed to the objectively scored type of examination. Some are advocating the importance of less individual laboratory work and more demonstration and explanation of experiments by the teacher. Withal, a critical eye is being cast upon the whole question of teaching chemistry.

Some schools are attempting to distinguish between students who come to them with and without high school chemistry by handling them in separate sections. Approximately 60% of the freshmen entering Purdue University in the fall of 1935 have had courses of chemistry in high school.

In addition to the courses shown in the tables, advanced courses are offered at the four schools giving graduate work, the number of such advanced courses being about 28 at Notre Dame, 31 at Indiana University, and 40 at Purdue University.

TABLE I

The number of credits for courses in chemistry in the several schools listed, as taken from current catalogs.

SCHOOL	Location	Date of Founding	Approximate Enrollment	General Inorg. Chem.	Qual. Analysis	Quan. Analysis	Organic Chem.	Phys. Chem.	Physiol. Bio-Chem.	Advanced Inorg. Chem.	Methods of Teaching Chem.	Miscellaneous
Ball State Teachers' College	Muncie	1918		8	8	8	8	4	4		4	4 (Special probs.) 4 (Applied Chem.)
Butler University	Indianapolis	1855	1500	10	5	5 (f)	10 (f)	5		5	2	1 (Premedic)
Central Normal College	Danville	1876										
DePauw University	Greencastle	1837	1400	6(c) 10	3(c) 5	3(c) 5	3(c) 10	4	3	2	2	1(Chem. Ger.) 1 (Chem. Fr.)
Earlham College	Richmond	1837	400	6(c) 8	(d)	6	18	2-4 (e)	3(c) 2-4(e)	4	2	6 (Agr.)
Evansville College	Evansville	1854	300	6(c) 10	5	5	6(c) 10	5	3			
Franlin College	Franklin	1824	300	8(c)	(d)	5	10	5			2	
Goshen College	Goshen	1894	300	6	8	6	2(c) 4			1-2 (e)	2	
Hanover College	Hanover	1827	400	10	4(c) 5	4(c) 5	10	4-6 (e)			2	
Indiana Central College.......	Indianapolis	1905	400	10	2-5 (e)	6-10 (e)	10	3		3	2	5 (Household)
Indiana State Teachers' College	Terre Haute	1865	3000	4(c) 8	4	8	12	8				4(Industrial)
Indiana University	Bloomington	1820	4600	10	5	7-11 (e)	8	4	6	4		
Manchester College (a)	North Manchester	1889	400	12	4	10	10	4		4	4	5 (Theoretical)

Marion College(a)	Marion	1920	200	15	5	15	15	3	10		4	5 (Agri.)
Notre Dame University	Notre Dame	1842	2600	4(c) 6	4	4(c) 8	8	3(c) 10	7			
Purdue University	West Lafayette	1869	3700	4(c) 6 8 (g)	3(c) 8(g)	3(c) 8	6(c) 10	3(c) 6 4(h)	6(c) 7			
Rose Polytechnical Institute	Terre Haute	1874	200	8	2	5	9	6				6(Industrial)
St.-Mary-of-the-Woods College	Terre Haute	1840	200	8	6	3	11	3	4		2	2(Chem. History)
St. Mary's College	South Bend	1855	200	10	4	4	8	10	4	8		2(Chem. Hist.) 8(Industrial)
St. Joseph's College	Rensselaer	1891	150	8	4		8					
Taylor College	Upland	1846	200	10	5	5	11	5		2-3(e)	2	2 (Chem. Hist.)
Tri-State College(b)	Angola	1884		2	1	2	2	1				
Valparaiso University	Valparaiso	1859	500	9	2	7-8(e)	8	3	3		2	3(Industrial)
Wabash College	Crawfordsville	1832	400	8	4	4	14	4			2	

(a) Credit hours based on quarter system rather than semester.
(b) Credit hours listed indicate merely semesters spent on subject.
(c) Light course and also heavier courses for benefit of those majoring in chemistry.
(d) Qualitative course included in General course.
(e) Variable-credit course; credit dependent on amount of work done.
(f) Additional laboratory work given for those desiring same.
(g) Divided into regular and rapid-pace sections for the benefit of those having had a good course in high-school chemistry.
(h) Entirely a laboratory course to be taken in addition to the lecture course if so desired.

TABLE II

Statistics of staff, students, and degrees granted for 20 schools answering our questionnaire

School	Staff			Students in Beginning Courses	Majors Graduated				Graduate Students Last Year	Degrees		Accommodate	
	Prof	Instruc	Assist		1932	1933	1934	1935		M.S.	Ph.D.	Beginning	Advanced
Ball State Teachers' College	1	1	2	90	11	10	13	12	No graduate work	0	0	150	75
Butler University	1	1	1		11	11	11	16	2	0	0	360	120
Central Normal College	2	1	3	12	5	7	6	8	None	0	0	60	36
DePauw University	3	1	1	115	7	12	10	13	None	0	0	210	125
Earlham College	1	1		55	2	2	6	7	No graduate work	0	0	108	All courses
Evansville college	1		1	11	3	1	5	1	0	0	0	32	36
Franklin College	1		3	31	5	1	5	2	0	0	0	18	21
Hanover College	1	0	2	30	3	2	1	7	No graduate work	0	0	56	32
Huntington College	1			27		1	1	1	0	0	0	56	21
Indiana State Teachers College	2	0	0	70	12	11	10	12	0	0	0	200	100
Indiana University	6	1	13	551	68	57	57	15	51	18	1	612	
Manchester College	2		5	72	5	5	9	6	0	0	0	96	32
Notre Dame University	6	3	11	290	31	39	15	15	28	8	5	510	350
Purdue University	13	1	11	1725	63	65	93	97	66	3	6	1701	772
Rose Polytechnical Institute	2	1		52	9	10	9	11	0	0	0	106	64
St. Mary's-of-the-Woods College	1		1		3	5	0	2	0	0	0	32	16
Taylor University	1		1	17	3	1	1	6	0	0	0	18	36
Tri-State College					27	21	29	13				28	
Valparaiso University	2	1	2	67	1	3	5	3	0	0	0	250	130
Wabash College	1	1	1	70	2	5	1	3	0	0	0	30 50 without Lab.	30

The emphasis on research has changed very materially since the situation was reviewed by Mahin (8) in 1920.

Fellowships subsidized by various manufacturers have helped. In some cases such outside connections have led to special organizations to take care of the situation. At Purdue University the Purdue Research Foundation was set up in 1930.

Better equipment and improved laboratory facilities have also greatly aided research, and with this has come also more encouragement and support from administrative officers.

In the beginning of chemistry instruction in Indiana, such a thing as a chemistry library probably did not exist, though text books and an occasional reference are mentioned. Silliman's chemistry seems to have been a popular text, though Roscoe, Stackhard, Elliott and Storer, and Youman are all mentioned. Occasionally a few reference books are mentioned, but the chemical libraries evidently were not extensive. We find in a statement of one college that to the reference books in chemistry there had been added a Webster's Dictionary. As chemistry has steadily grown in Indiana, the demand for reference books has increased until today some of the larger schools have fairly extensive departmental libraries containing not only the best reference books but journals, both current and back volumes. Today the chemical libraries in the state probably represent a fairly good sample of chemical literature, both past and present. In 1931, out of a list of 2,000 periodicals abstracted by Chemical Abstracts, the four ranking libraries of the state are credited with having the following number of these periodicals: Purdue University, 293; Indiana University, 186; Indianapolis Public Library, 115; University of Notre Dame, 96. No attempt has been made to list these journals, as this information can be found elsewhere.

In conclusion, may we not say with all modesty that much is being achieved in chemical education in Indiana today, but may we not also look ahead to advances today undreamed of when the Indiana Academy of Science celebrates its centennial in the year 1985?

The writers wish to express their thanks to all those members of the various departments of chemistry in the Indiana colleges who have so kindly furnished them with information included in this paper.

Bibliography

1. Victor H. Noll, 1935. Jour. Chem. Ed. 12:475.

2. Robert B. Warder. Title included in list of papers presented at the first meeting of the Indiana Acad. Sci., Dec. 29, 1885. There is no record of its having been published.

3. J. H. Ransom, 1916. Proc. Ind. Acad. Sci. 35:389.

4. R. E. Lyons: A History of Chemistry at Indiana University 1829-1931.

5. Theodore H. Ristine: A Digest of the Minutes of the Board of Trustees of Wabash College (1832-1922).

6. Purdue University Alumni Directory 1875-1934.

7. M. G. Mellon and L. A. Test, 1931. Jour. Chem. Ed. 8:1208.

8. E. G. Mahin, 1926. Proc. Ind. Acad. Sci. 36:275.

PROGRAM OF THE SECTION ON GEOLOGY AND GEOGRAPHY

Chairman: C. A. **Malott**, Indiana University

1. *Features of the valley floor of the Wabash River near Vincennes. M. M. Fidlar, Indiana University.
2. Stratigraphic relations of the Merom sandstone, near Merom, Indiana. M. M. Fidlar, Indiana University.
3. Karst valleys. Clyde A. Malott, Indiana University.
4. Some trends in commercial products. J. E. Switzer, Indiana University.
5. Ages of the silts in glacial Lake Cynthiana. W. D. Thornbury, Indiana University.
6. Some problems in glacial drainage in the vicinity of Fort Wayne, Indiana. Fred J. Breeze, Fort Wayne.
7. The Köppen system of climates. An American academic adaptation. A. H. Meyer, Valparaiso University. (Read by title.)

The paper by S. S. Visher, on Indiana Regional Contrasts in Temperature and Precipitation, which was presented in the General Session (See Program, p. 9), is published in this section.

---

*Papers published in this volume.

FEATURES OF THE VALLEY FLOOR OF THE WABASH RIVER NEAR VINCENNES, INDIANA

M. M. FIDLAR, Indiana University

Introduction

It is the purpose of this paper to set forth the characteristics of the valley floor of the lower Wabash River in the vicinity of Vincennes, Indiana, and to present theories concerning the development of the physiographic features found therein. The valley floor is in reality a valley plain in the region about Vincennes, where it attains a width of slightly more than ten miles. This width is approximately retained south of the area mapped (Fig. 1), and in the vicinity of the junction of the Wabash and Ohio rivers the valley plain expands to a breadth of more than fifteen miles. North of Vincennes, the valley floor of the Wabash gradually decreases in width to approximately four miles near Terre Haute, and to even less than this farther north. Much of the physiographic history of the region is related directly or indirectly to glaciation and its attendant phenomena. Eolian processes have also played an important part in the development of the surface features of the valley floor. Forms within the valley floor include alluvial terraces, lacustrine terraces and flats, valley braids and valley braid cores, floodplain features, sand dunes, and loessial deposits. Certain of these features are unusual and have had a very interesting physiographic development.

Physiographic Forms and Their Development

Pre-Wisconsin Development.—The valley of the lower Wabash in pre-Illinoian time was probably in the late maturity stage of the erosion cycle. The master valley itself was broad, and the valley sides were relatively gentle. For the most part, the valleys of the smaller tributary streams must have been graded to the master valley. In the interval between late Tertiary time and the advent of the Illinoian ice invasion, the lands had been warped upward, and the Lafayette gravels (Pliocene?) had been lifted to their present position high above the present base-level.

The Illinoian ice sheets covered nearly all of the lower Wabash region, and the terminus of the continental glacier lay some forty miles southwest of the southern limit of the mapped area (Fig. 1). It is highly probable that most of the valley of the Wabash River was at that time filled with glacial drift, both till and glacio-fluviatile deposits. As the ice receded, the Wabash and some of its tributaries must have acted as sluiceways for the melt waters from the waning ice sheet. If the valleys carrying the melt waters were filled with materials of Illinoian age, most of the deposits must have been removed in the interval between Illinoian and Wisconsin time, for only Wisconsin materials can be identified at the surface of the valleys at present.

Shelbyville Terrace.—As the Wisconsin glacier advanced upon the region from the north, the Wabash valley served as a sluiceway or discharge route for the melt waters from the ice front. The waters poured down the valley, carrying great amounts of detrital materials from the

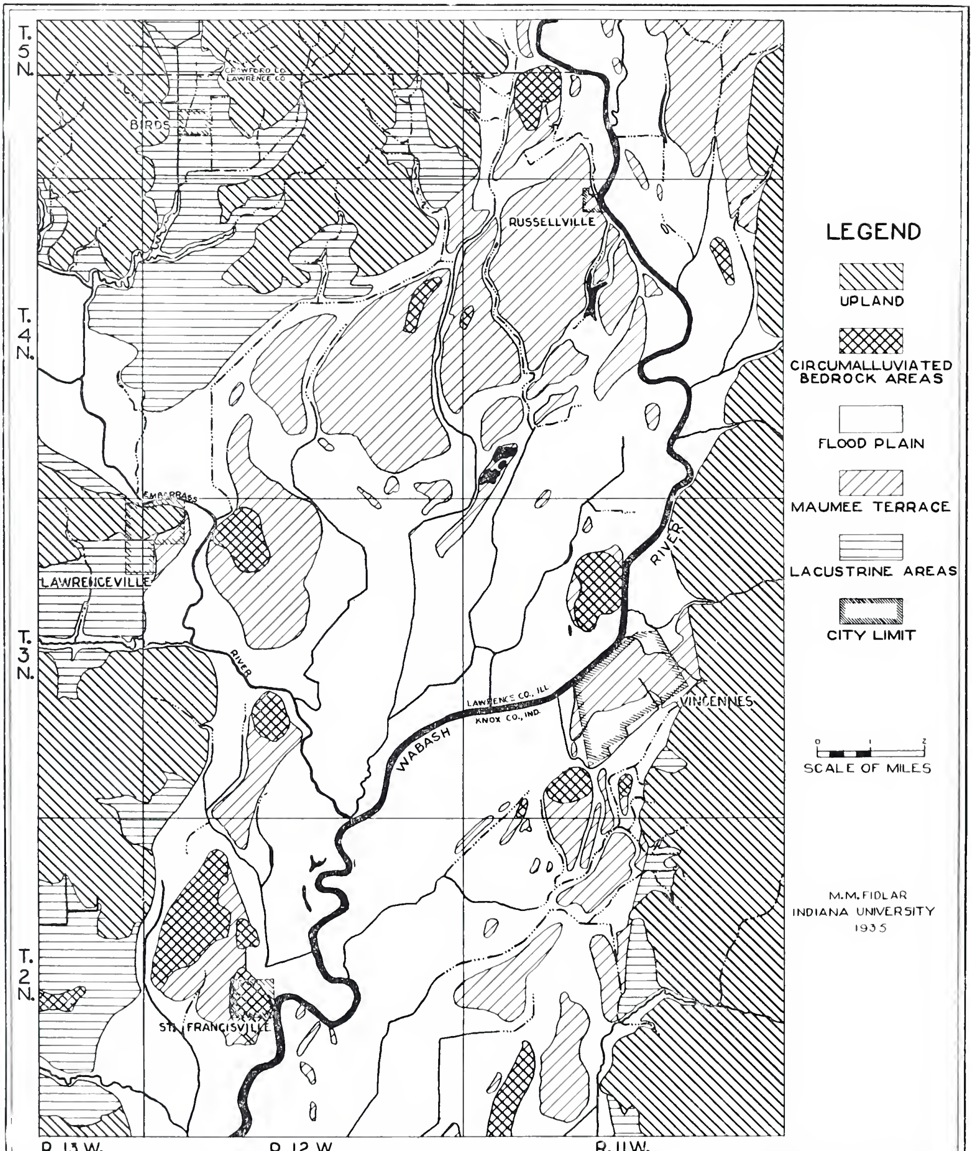


FIG. 1. Map of the Wabash valley region of Illinois and Indiana in the vicinity of Vincennes, showing the principal physiographic features upon and adjacent to the valley floor.

ice, burying portions of the upland in a great valley train, and planing away at the foundations of the valley sides. At the maximum extension of the ice in Wisconsin time, the terminus of the glacier crossed the lower Wabash valley at a point about forty-five miles north of the mapped area. At this time, valley-filling reached its maximum, and portions of the old upland were completely buried beneath the valley train materials. As the ice again withdrew to the north, waters continued to discharge down the Wabash valley, but the greater part of their detrital load was probably deposited north of the Shelbyville moraine.

The Shelbyville terrace, or the surface of the maximum valley-fill in Wisconsin time when the ice lay at the Shelbyville moraine, is not represented in the Wabash valley proper in the region discussed in this paper, nor can it be identified farther south in the valley, where terraces and floodplain merge imperceptibly into one another. However, other terraces in the region near Vincennes indicate the approximate level to which the master valley was once filled. These are the lacustrine flats, found in the larger tributaries to the Wabash.

Lacustrine Flats.—At the time that the Wisconsin ice front stood at the Shelbyville moraine, the vast amounts of sands and gravels transported and deposited by the melt waters coursing down the Wabash valley filled the deeper portions of the valley to depths as great as more than 100 feet. Coincident with the deposition of this great valley train, the waters were also cutting at the base of the upland borders. Rather expansive stretches of bedrock upland were planed down to a level slightly below the surface of the glacial river and were buried beneath a thin veneer of sand and gravel. The valley train of the Wabash was constructed so rapidly that the smaller tributary streams could not keep pace in building up their floors. This was especially true of those which received no melt waters. As a consequence, the smaller streams were ponded in their lower courses by the gravel train and water in the master valley, and a series of lakes was formed on each side of the lower Wabash valley. The floors of these tributary valley lakes were slowly raised by the deposition of calcareous silts and finely-laminated, tough, fatty clays carried in by the streams which were ponded and by backwaters from the flooded glacial stream. The resulting lacustrine flats were developed at the level of the surface of the Shelbyville fill before the lakes were destroyed. The elevation of the lacustrine surfaces is, then, dependent upon the height to which the Wabash valley floor was constructed at the point where each individual ponded tributary entered the master valley. That the lacustrine flats are Shelbyville in age is perhaps demonstrated by the fact that evidence of ponded tributaries north of the Shelbyville moraine is apparently lacking.

The small lacustrine flat west of Russellville, Illinois, has an elevation of 450 to 460 feet above sea level. The floor of glacial Lake Birds, north of Lawrenceville, Illinois, stands 440 to 460 feet above sea level. The altitude of the "Sand Barrens" along Raccoon Creek, west of St. Francisville, Illinois, is 420 to 440 feet. Most of the lacustrine flats along the eastern side of the master valley are heavily masked by eolian sands, blown up from the alluvial materials of the Wabash valley train, and it is nearly impossible to ascertain here the exact altitudes of the old lacustrine floors.

A comparison of altitudes shows that the surface of the lacustrine deposits lies from 10 to 30 feet above the surface of the Maumee terrace, described elsewhere in this paper. The decreasing difference in altitude, from north to south, between the Maumee terrace level and the Shelbyville lacustrine flats indicates that the Shelbyville valley train surface must have had a gradient in excess of ten inches per mile.

Valley Braids and Valley Braid Cores.—As the waters deposited valley train alluvium in Shelbyville time, the floor was constructed increasingly higher, until the river occasionally spilled over lower places in upland spurs between tributaries of the main valley, cleaning away the residual materials and wearing down the bedrock of this newly selected and alternative route. The composite valley consisted of several interlacing parts, all occupied by the great glacial river. Features of this type have been described in the upper Wabash valley by Malott and Shrock,[1] as follows: "*Valley braid* is a term proposed for the individual runway of a valley which is in anastomosis, its valley parts passing around features in bas-relief or about upland tracts. The floors of the valley braids may be near the level of the one which carries the present stream, or they may be much higher. Valley braids are numerous in some stretches of the Wabash sluiceway." In the upper portion of the Wabash valley, the valley braids are sharp channels; the circumscribed upland tracts are broad and are less conspicuous.

In the lower Wabash valley, however, the upland tracts are the conspicuous features. The valley braids have become so broad and are so merged as to resemble an expansive local plain. The isolated upland remnants rise spectacularly from this veritable sea of alluvium. Owing to the lateral extension of the floors of the valley braids by a combination of erosion and alluviation, the bas-relief features have been reduced to mere fragmentary masses of upland, often separated from the upland sides of the Wabash valley by several miles of alluvial floor. In the region discussed in this paper, however, most of the circumalluviated bedrock masses lie reasonably near to the sides of the present valley. The writer[2] has proposed the name *valley braid core* for the isolated, fragmentary upland masses, circumscribed by the over-widened valley braids. The valley braids may or may not be occupied at the present time by channel or floodplain.

The valley braid cores in the Vincennes region attain a part of their height above the valley floor by virtue of sands blown from the valley train materials below. Bedrock is nearly always exposed somewhere near the base of the cores, especially if a portion of the present floodplain passes beside them. The surface of the Wilbur Hills, north of Russellville, exhibits typical ancient dune topography, as does that of the upland remnant on Sand Ridge, just east of Lawrenceville. The small bedrock area three miles southwest of Russellville is covered with a shallow blanket of wind-blown sand, and the planed surface of the bedrock stands only a few feet above the level of the Maumee terrace at this point. It is probable that this portion of the bedrock upland was completely buried by the valley fill in Shelbyville time and that the excavation of a later erosional level has uncovered it again.

---

[1] Malott, C. A., and Shrock, R. R., 1929. Features of the Wabash sluiceway of northern Indiana. Bull. Geol. Soc. Amer., **40**:102.

[2] Fidlar, M. M., 1933. Some hills of circumalluviation in the Lower Wabash Valley. Proc. Indiana Acad. Sci., **42**:135-140.

Robeson Hills, the valley braid core in Illinois just north of Vincennes, present a very interesting situation. This core is separated from the upland at the eastern edge of the Wabash valley by a narrow valley braid, the floor of which is only thinly veneered with sands and gravels. The valley braid core certainly represents the end of a spur formerly jutting into the old valley. The spur was dissected, probably during the Shelbyville stage, when the floor of the Wabash valley had been aggraded to an extent sufficient to allow the melt waters to pour over a low place in the spur. In the final adjustment at the close of the Pleistocene, the Wabash inherited the newer route through the restricted fluve, in lieu of a course in the older six-mile expanse of the valley braid to the west of the Robeson Hills.

Maumee Terrace.—Following the withdrawal of the ice sheet to the northeast from the Shelbyville moraine, it paused successively at the Bloomington, Union City, Mississinewa, Salamonie, Wabash, and Fort Wayne recessional moraines. At each of these points, melt waters possibly constructed a terrace in the sluiceway similar to the Shelbyville level. These same waters, after depositing a portion of their detrital load, may have cut into the Shelbyville fill, so that by the time the ice sheet reached the Fort Wayne moraine, several terrace levels may have been present throughout the entire Wabash sluiceway. In late Wisconsin time, the melt waters from the ice collected at the southern edge of the lobe to form glacial Lake Maumee, of which the present Lake Erie is a remnant. The waters from the ancient lake spilled over the edge of the basin in the vicinity of Fort Wayne, Indiana, and poured across the country to join the present route of the Wabash River at Huntington, Indiana. This water was much clearer than that which was discharged directly from the front of the ice sheet when it stood at the various moraines. As a consequence, this water during the Maumee stage may have erased the traces of other erosional terraces developed in the alluvial fill and cut a lower level. It is the writer's opinion that much of the erosion of the fill was accomplished during the Maumee stage of the Wisconsin ice age. Only a few scattered remnants of the surface of the Shelbyville alluvium were preserved.

The terrace or erosional level resulting from the work of the Maumee waters is very conspicuous in the region around Vincennes. This city is built partially upon a large remnant of the Maumee terrace. Since its development in late Wisconsin time, the Maumee level has been excavated and destroyed to a great extent by the development of an expansive floodplain. The surface of the Maumee terrace stands 425 to 430 feet above sea level at the northern edge of the mapped area, and slopes down-stream with a gradient of eight inches per mile, reaching an elevation of 410 to 413 feet at the southern end of the region. The floodplain of the Wabash in this area has a gradient of only seven inches per mile. To account for the difference in gradient, it would be safe to assume that the waters which carved the Maumee level, although relatively clear when compared to the waters directly from the front of the ice, were more heavily laden with detrital materials than are the present flood waters, and consequently the floor over which they flowed required a steeper gradient to facilitate the seaward movement of the alluvial materials.

Many of the remnants of the Maumee level are covered with heaps and mounds of wind-blown sand. As the prevailing westerly winds moved the sands of the valley floor, some of them came to rest upon these strips of terrace 10 to 15 feet above the reach of the high flood waters. These dunes, then, within the valley plain, must necessarily be late Pleistocene to Recent in age. The terrace remnant just east of Lawrenceville, Illinois, is nearly entirely covered with sand swept from the lacustrine flats and the floodplain to the south and southwest. For this reason, it is locally named "Sand Ridge."

In places where the Maumee level is not covered by dunes, the present surface soil is gravelly and sandy. It is in such localities that many of the gravel pits of the region are located. The largest gravel pit in the Wabash valley in Illinois is located in one of the Maumee remnants, about six and three-fourths miles slightly north of east of the city limits of Lawrenceville.

Floodplain and Anastomosing Fluves.—Since the cutting of the Maumee level or terrace in the gravels and sands of the valley plain, the Wabash River has excavated a floodplain at a lower level. The gradient of the floodplain in the region under consideration is approximately seven inches per mile, while the gradient of the channel of the river is about six inches per mile. This discrepancy exists because of the fact that the channel winds through the floodplain. The floodplain is 415 feet above sea level at the northern end of the mapped area, and its elevation is 402 feet at the southern end. The floodplain in this region is not a simple one, developed adjacent to the channel, but is a very complex system of anastomosing flood water fluves. An especially interesting set of such intertwining routes is to be found between Russellville and Lawrenceville, Illinois. Here some of the floodplain fluves are extremely narrow. One of the flood water routes leaves the river at the extreme northern edge of the area and follows the western side of the valley to the southern limit of the mapped region. The Embarrass River enters this fluve at Lawrenceville, follows it for several miles, and then turns southeast to join the Wabash. A series of small, restricted floodplain fluves surround portions of the Maumee erosional terrace and some remnants of the partially-buried upland in the region south of Vincennes, Indiana.

The channel of the Wabash in this vicinity is developed 15 to 20 feet below the surface of the floodplain. It is cut, for the most part, in the materials of the Shelbyville valley train. In some places, however, bedrock is exposed in the floor or sides of the channel. Perhaps the most notable of these places occurs in the restricted valley braid between Robeson Hills and Old Fort Knox, on the upland to the east. Owing to the shifting of the river over its alluvial floor, many channel scars and partially-silted meander routes are to be found on the floodplain throughout the entire lower Wabash valley. These features are not so conspicuous in the area under consideration as they are to the north and south.

Summary

From the evidence cited in the preceding pages, it is apparent that the lower Wabash River has not undergone a normal cycle of development. Little evidence can be found that sheds any light upon the physiographic situation in the Wabash valley following the withdrawal of the Illinoian ice sheet. The valley may have been filled with drift as the ice rode over it. In any case, it was cleared out by the pre-Wisconsin Wabash River to a level below the present base-level. No Illinoian materials can be found within the valley proper. During the Shelbyville stage of the Wisconsin ice invasion, the valley was filled with outwash materials in the form of a valley train. In the region discussed, alluviation reached its peak at the time that the ice stood farthest south in Indiana. The great amount of water and the rapid aggradation of the valley floor of the Wabash induced the ponding of the tributaries and the consequent construction of lacustrine flats, dependent upon the level of the valley train of the master stream at the points where the tributaries entered the main stream. It was also during this stage that valley braids and valley braid cores were developed extensively by a combination of alluviation and erosion. The period of greatest aggradation in the region was probably followed by a period of continuous removal of a part of the alluvial fill, climaxed by the erosion of the Maumee level, when the waters of glacial Lake Maumee discharged down the sluiceway. In more recent time, a floodplain, composed of anastomosing flood water fluves, has been carved below the Maumee erosional terrace.

The writer wishes to call attention to some misconceptions concerning the development of the broad expanse of valley floor of the Wabash River. The topography of the region would certainly suggest that the great valley expanse had been carved during a normal erosion cycle, and that the region as a whole represented an area in the old-age stage of the cycle of land reduction. However, this is certainly not the case. The valley plain of the lower Wabash is not a true degradational floor, such as would be found in a normal valley; rather, it is aggradational in character.

In Professional Paper 60, United States Geological Survey, "The Interpretation of Topographic Maps," Salisbury and Atwood discuss a portion of the lower Wabash valley (pp. 33-34). They accept the region just south of the area mapped in this paper as a good illustration of old age topography. Some of the valley braid cores are brought to attention, and it is deduced that, since the hills standing in the valley flat reach nearly the same altitude as that of the upland, the great valley expanse has been *degraded* from the level represented by the hills and the adjacent upland border. The writer wishes to call attention to the fact that the isolated hills reach the altitude of the upland by virtue of a rather thick covering of eolian sands and loess. Further, the present surface of the valley, though it is truly degradational in character, is developed in a great mass of alluvium which at one time stood higher than the present valley floor, yet lacked many feet of ever reaching the top of the upland border. The true degradational floor of the valley lies in many places more than 100 feet beneath the present alluviated lowland floor.

This citation is only one of several instances where the lower Wabash valley has been proposed as an illustration of a valley in the old age stage of the cycle of erosion. However, fluvial erosion has reduced the bedrock floor of the Wabash valley to a point far beneath the present floor, and the area should not be taken as a typical example of a valley in perfect old age, since it has passed through an abnormal cycle of development.

INDIANA REGIONAL CONTRASTS IN TEMPERATURE AND PRECIPITATION

WITH SPECIAL ATTENTION TO THE LENGTH OF THE GROWING SEASON AND TO NON-AVERAGE TEMPERATURES AND RAINFALLS

STEPHEN S. VISHER, Indiana University

Introductory.—*The Problem:* How great are the regional contrasts in Indiana with respect to temperature and precipitation? What causes the contrasts? What significance do the contrasts have? *The Method:* The climatic data gathered during many years under the supervision of the U. S. Weather Bureau at the scores of scattered cooperative stations and the five full-time weather bureau stations in Indiana, together with data gathered at the nearby regular stations, Chicago, Cincinnati, and Louisville, supplied the data to establish the contrasts. In the following paper, 31 maps depict significant climatic contrasts. An understanding of the causes of the contrasts requires a knowledge of climatology and a consideration of the effects of Indiana's differences in latitude, altitude (Fig. 2), and relief, and relationship to Lake Michigan. The significance of the contrasts is suggested by comparisons among these 31 climatic maps (and fifteen others not published for lack of space) and numerous other maps showing distribution of crops, population, attainment, land values, etc. (At the close of the paper is a summary of the findings.)

Scores of patient volunteer observers have daily recorded the temperature, rainfall, and certain other climatic data for their localities, since 1914 under the able supervision of J. H. Armington, state director of the U. S. Weather Bureau, which maintains five full-time stations in Indiana, at Fort Wayne, Royal Center, Terre Haute, Evansville, and the state headquarters, Indianapolis. The popular interest in climatic data has been less widespread in Indiana, however, than in many other states, which fact reflects the dependability of our climate. Indiana generally receives almost enough rainfall and seldom a great excess; it generally has enough warmth and seldom a great excess; neither early nor late freezing temperatures interfere seriously with the growing of our main crops. Moreover, destructive storms are rare in Indiana. Because of this very excellence of Indiana's climate, it has been studied less fully than that of many other areas. Indeed, this paper appears to be the first on Indiana's climate which has been presented before the Academy. In less fortunate states, Iowa for example, the greater irregularity of rainfall and the greater extremes of temperature led many of even the earlier settlers to appreciate the great importance of rainfall and temperature. As a result, Iowa has many more long rainfall records than has Indiana. Our longest records are for Vevay (Switzerland County) (69 years), Richmond (65), Indianapolis (64), Evansville (58), Terre Haute (57), Lafayette (56), Logansport (56), Mauzy (Rush C.) (54), Farmland (Randolph C.) (53), Elliston (Greene C.) (53), Jeffersonville, Marengo, and Princeton (52), Bloomington and Columbus (51), and Rockville (50). There are 88 stations in the state at present, nine of which have less than ten years of records. In addition, earlier records are available for several localities not now represented.

After a sufficient number of climatic data have been gathered, they may be presented in tables and summarized on maps. Averages have commonly been considered of chief importance, and hence until recently, most published presentation of Indiana climatic data has been of averages, moreover, chiefly annual averages.[1] So far as their influence upon living things is concerned, annual averages are of little significance. The atmospheric conditions which clearly affect life are the actual ones which occur, not averages. The extremes are of particular significance as setting limits which must be withstood. Hence the conventional tables and maps of average annual rainfall and temperature should be supplemented as fully as possible by tables and maps showing extremes and the duration of specific conditions, such as freezing temperatures and periods with inadequate rainfall.

As a geographer, I am especially interested in the effects of the contrasts, but all scientists are interested in causes. The causes of observed contrasts in Indiana's climate are by no means all fully understood, and some are due to such complicated influences that it is impractical to try to present even a summary. However, a few great causes can be advantageously pointed out.[2]

Regional Contrasts in Temperature

The northward decline in temperature shown by Figure 1, and almost all other maps of Indiana's temperatures, is due to the decreasing effectiveness of the sun's rays, resulting from the lower angle of the sun at noon.

Although the chief influence affecting average temperature is latitude, altitude plays an observable role; hence a map of elevations is illuminating. Figure 2 shows Indiana's altitudes in a generalized way, omitting the minor irregularities. It reveals that the lower Wabash and Ohio valleys are less than 500 feet above sea level, but that on the east are areas above 1,000 feet. The 800-foot contour line, through the section having an altitude of 500 to 900 feet, calls attention to the close approach of highlands to the lowlands along the Ohio River and Lake Michigan.

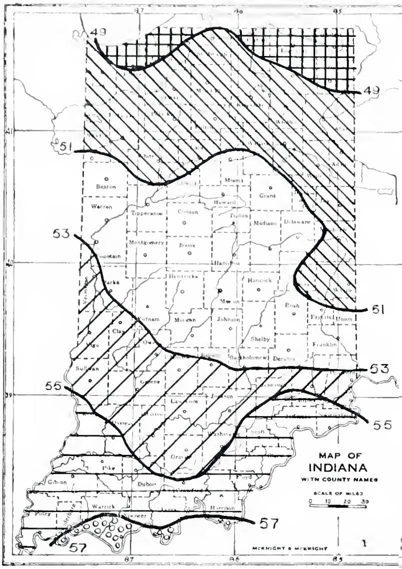
The influence of differences in altitude are shown on many of the following maps, and it will be worth while to compare them repeatedly with Figure 2.

---

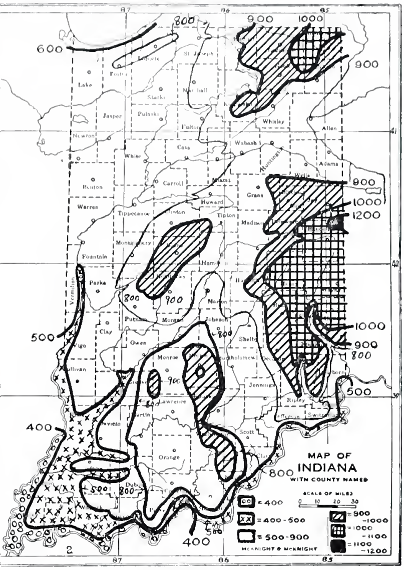
[1] The only published climatic maps of Indiana known to the writer, aside from his own, are of average annual precipitation and temperature, average length of growing season, and average dates of last and first killing frosts. These are all based on far fewer data than the maps here given. Director J. H. Armington of the Indiana section of the Weather Bureau has presented three editions of tables of averages dealing with the data accumulated up to 1915, 1922, and 1930. The last was published in 1933 and is called "Climatic Summary of the United States. Climatic Data from the Establishment of the Stations up to 1930. Section 66 Northern Indiana, Section 67, Southern Indiana." For sale for 10 cents each by the Superintendent of Documents, Washington, D. C.

The data used in making most of the following maps were obtained in this latest publication, except that the several maps of extremes and of the growing season considered also data given in the annual reports for 1931 to 1934, inclusive. Other data were obtained from recent issues of the Monthly Weather Review, the Atlas of American Agriculture, and other dependable sources.

[2] Much more extended discussions than are here appropriate may be found in the following by the author: Climatic laws, New York, 1924; Climate of Kentucky, Frankfort, 1929; Economic geography of Indiana, New York, 1923.

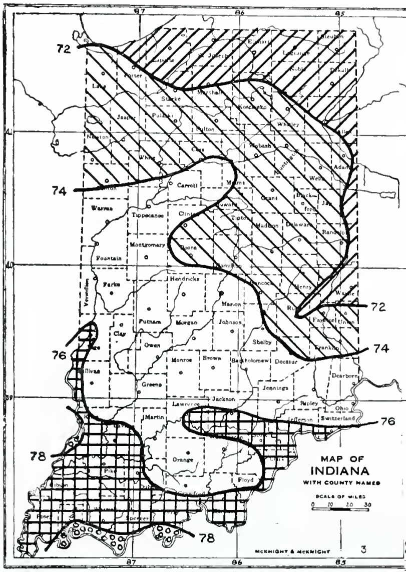


1

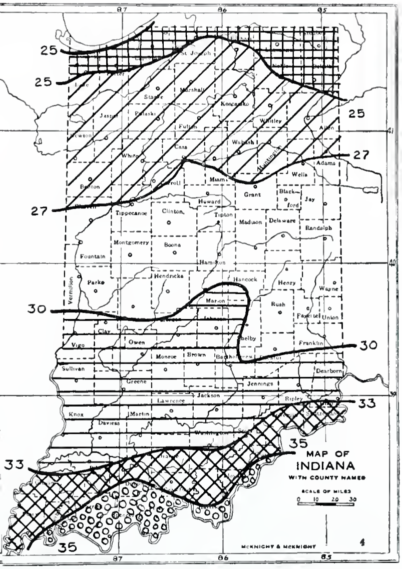


2

FIG. 1. Annual average temperature in degrees.
FIG. 2. Elevation in feet above sea level (generalized). Data from U. S. Geological Surv., C. A. Malott, and others.



3



4

FIG. 3. July and August average temperatures.
FIG. 4. January and February average temperatures.

Figure 3, of the average July and August temperature, reveals much less contrast with latitude than does Figure 1, but it shows at several points the influence of altitude more clearly than does Figure 1. The warmest section is along the Ohio River and lower Wabash, while the most elevated section at the northeast and east is the coolest. Most of the state has an average of 72° to 76°, which, although excellent for our chief crop, is distinctly too high for the best efficiency of man.

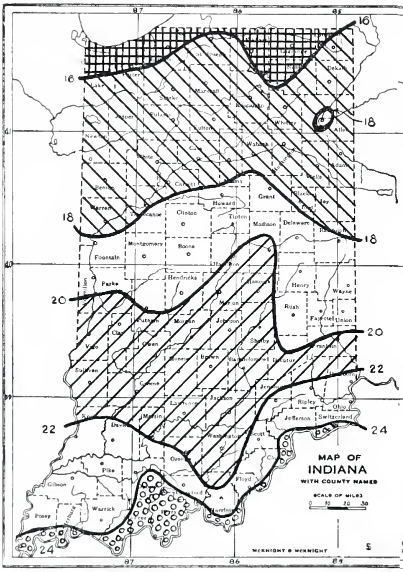
Figure 4 shows the average temperature for January and February. (These two months are so much alike in Indiana that it is desirable to consider them together. For similar reasons July and August are considered together.) This figure reveals that the contrast between the extreme northern and southern sections is twice as great in midwinter as in midsummer.

As the highest and lowest temperatures are of especial significance, the foregoing maps of average summer and winter temperatures should be supplemented by maps showing maximum and minimum temperatures.

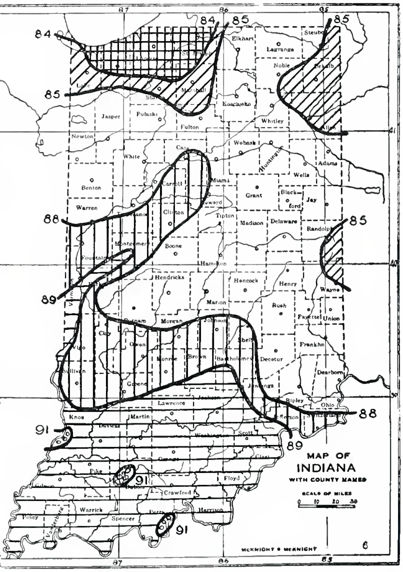
Temperature Extremes.—Figure 5, of the average daily lowest temperatures, shows that in January the temperature falls to about 20° each night in the central part of the state but to 16° at the north and 24° at the south.

Figure 6 shows that the coolest part of the state on July afternoons is near Lake Michigan, but that nearly all of the state has a truly tropical temperature, is warmer, indeed, than most parts of the tropics, which never have long days and short nights.

Turning now to the lowest temperatures of winter, we note that nearly every winter temperatures lower than -10° are experienced

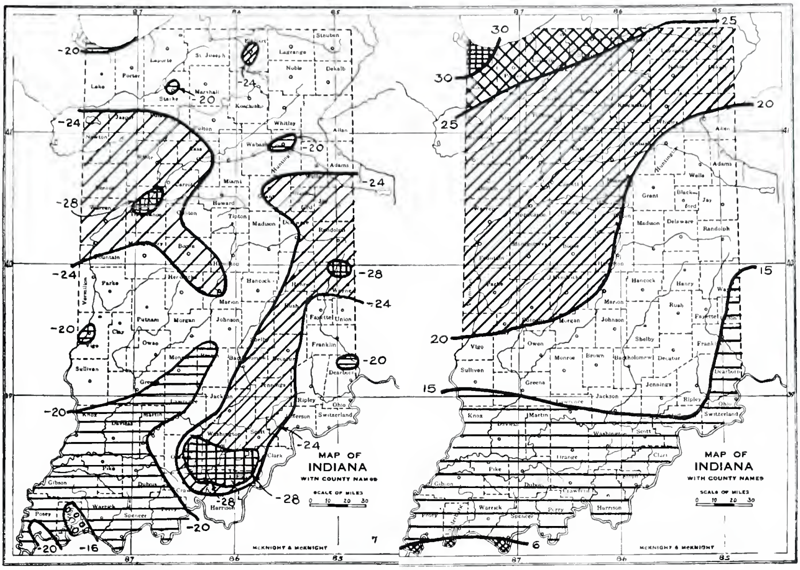


5



6

FIG. 5. Minimum temperatures, daily average for January.
FIG. 6. Maximum temperatures, daily average for July.



7 8

FIG. 7. Lowest temperatures ever officially recorded (to 1935).
FIG. 8. Average frost penetration (inches).

throughout the northern half of Indiana and temperatures of -5° in the southern third. In only one-fifth of the years, indeed, is the lowest temperature at Indianapolis warmer than 12° below. The corresponding figure for Royal Center is -18°, for Chicago, -16°, and for Terre Haute and Evansville, -10°.

The lowest temperatures ever officially recorded up to 1935 at the weather stations are the basis for Figure 7. This shows that nearly all parts have had temperatures of more than 20° below zero, and the three areas which have been colder than 28 below include one on the elevated area near the southern margin of the state. The official records are -33° at Lafayette (1887) and -30° at Marengo (Dec. 1917), with nearby stations approaching those figures. The warmest spots, if -16° and -18° may be thought of as warm, are Evansville and two near Lake Michigan.

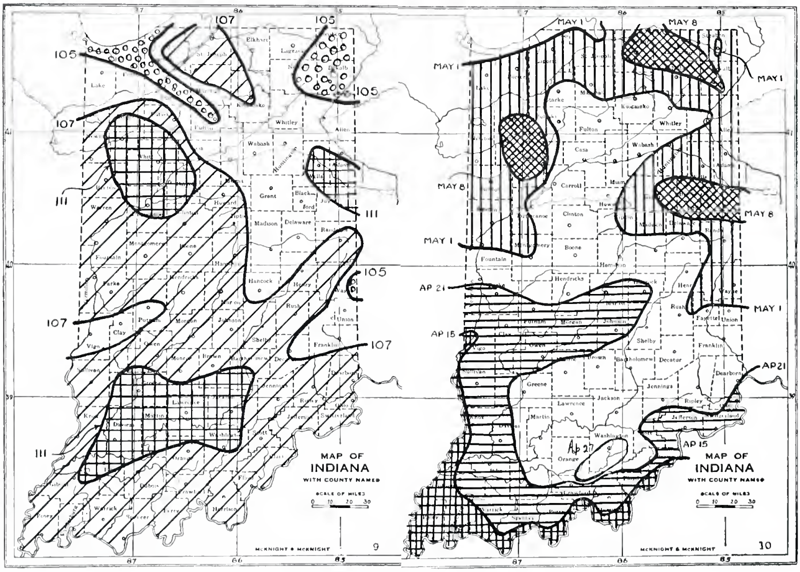
Although there is not much correlation of latitude or altitude with very low temperature records in Indiana, there is, nevertheless, considerable correlation of latitude with the frequency and duration of very cold weather. For example, subzero weather is experienced on seven days each winter, on the average, at Fort Wayne and Royal Center, four or five days at Terre Haute and Indianapolis, and only one or two days at the southern margin of the state.

A map (not published) showing the average number of days which have a minimum temperature below freezing, reveals that, in this respect, the northeast corner of the state is considerably colder than the southwest, the range being from about 75 days at Evansville to more than 120 days at the northeast. The central part of the state (Terre

Haute and Indianapolis) has frost on about 100 days, Royal Center on 128, and Fort Wayne on 121 days.

Figure 8 shows that in northwestern Indiana the ground freezes more than six times as deeply as at the south. The maximum depth of recorded frost penetration is sixty inches in the northwestern corner of the state, 48 inches in the northeast, 48 inches at Indianapolis, and 18 inches or less at the south (only five inches at Louisville). The northwestern corner of Indiana freezes deeper than the northeastern, because of the tempering effect on the latter of northwest winds off Lake Michigan and the greater snow cover.

An unpublished map shows the average date when the mean temperature (average of night and day) rises above 35°, which is February 16 along the Ohio River, about March 8 in central Indiana, and after March 16 in northern Indiana. Another shows that the mean daily temperature rises above 55° about April 23 in central Indiana, but a week earlier along the southern margin and a week later at the north. Temperatures above 55° are significant here as corn grows slowly when the temperature is below 55°. (Careful tests at Urbana, Illinois, have shown that corn grows hardly at all when the temperature is below 49°.) During July and August, as we saw in Figure 3, the average temperatures (day and night together) are close to 74° for most of the state. The temperature reaches 90° or more on 15 to 17 days in central Indiana during the normal summer, but on 34 days at Terre Haute and on 37 days at Evansville. In four-fifths of the years it reaches 98°, 99°, or higher at least once at all the widely scattered weather stations. In the other fifth of the years the highest temperature is somewhat below 98°.



9 10

FIG. 9. Highest temperatures ever officially recorded (to 1935).
FIG. 10. Date of average last killing frost in spring (96 stations).

Occasionally, especially during exceptionally dry periods, considerably higher temperatures are experienced. Figure 9, of the highest temperatures ever officially recorded up to 1935, shows that, except near Lake Michigan and in the elevated northeast area, temperatures of higher than 105° have been experienced. Indeed, all stations have had 105° or above except Richmond (102°), and stations near Lake Michigan (104°, 100°). The state records are 113° at Washington (1930) and at Collegeville, near Rensselaer (1934). Although there is not much regional difference in record high temperatures in Indiana, South Bend's record (109°) being higher than Evansville's (107°), nevertheless most of the northeastern third of the state has lower records than the rest. Moreover, very high temperatures are much more frequent in the south than in the north, and, until the exceptional summer of 1934 broke the heat records for most of northern Indiana, the contrast between north and south was notable. As late as 1933 several northern stations had never recorded higher than 103°, only a few had records higher than 105°, and none higher than 108°. The highest temperatures recorded at Fort Wayne during several decades was 102°, but in 1934 this record was broken by a temperature of 106°.

In the southern part of the state, almost all of the stations had temperatures of over 105° prior to 1922, and six stations had surpassed 110°. Many of the records for southern Indiana were established in 1930, but most of those for northern Indiana were established in 1934, both during exceptionally dry periods.

Although the record temperature of any summer may occur anywhere within a period of a week or two, the warmest 24 hours in most of Indiana comes on the average, on July 20, 30 days after the summer solstice. Close to Lake Michigan, however, the hottest average day is July 23 or 24, and along the Ohio River it is July 21.

Conversely, the coldest winter day in most of northern Indiana comes about 30 days after the winter solstice; near Lake Michigan it comes 32 days after, and in southern Indiana only 28 days after the solstice.

The Frost-Free Period or Growing Season

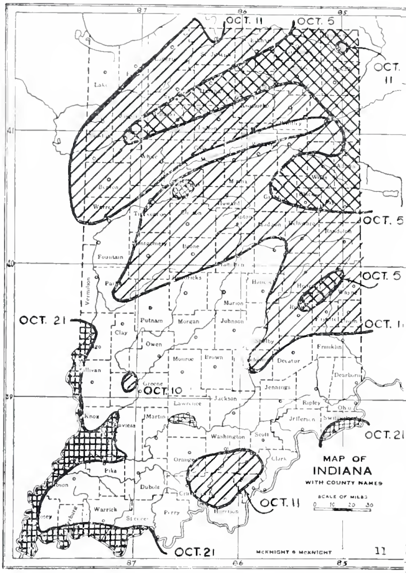
Because of their great effect upon plant growth and animal activity, freezing temperatures are of especial significance. Hence a series of maps have been prepared to show the dates of the last killing frost in spring and the first in the autumn, not only for the average year but for exceptional years, as well as for four years out of five. These maps are based upon all available data from 96 stations up to the end of 1934.[3]

Such frost maps as these are of value to agriculturists, and the corresponding maps of the length of the growing season reveal contrasts between different sections of Indiana which help explain various observed differences in flora and fauna.

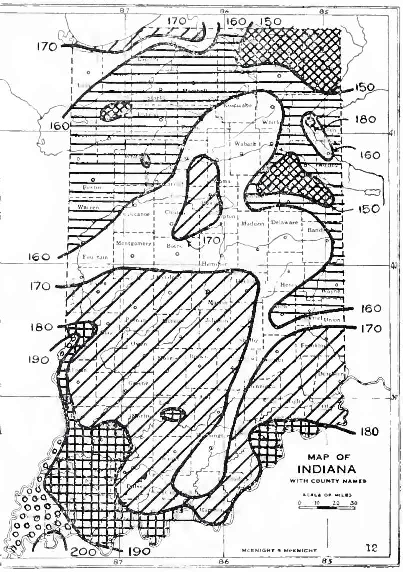
Average conditions: Figures 10, 11, and 12 deal with the average last killing frost in the spring, the first in the fall, and the interval

---

[3] These maps are far more detailed and correct than any hitherto prepared for Indiana. They are based not only on the 79 stations for which averages and extremes are given in the Summary to 1930 cited in footnote 1, p. 184, and upon the 43 stations of the 79 for which details are given therein, but upon 17 additional stations, for which the detailed data for 1901 to 1934 inclusive were compiled from the various annual reports. Data for 1931-1934 were also made use of for the other stations.



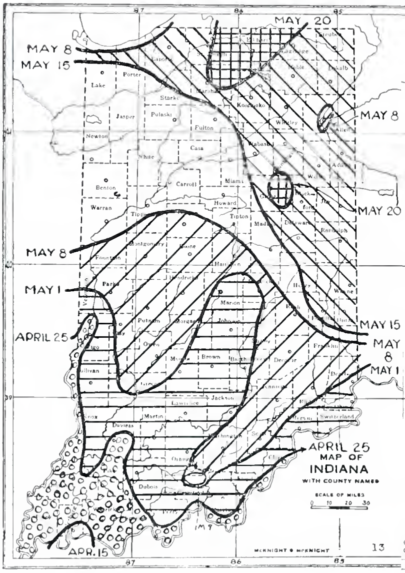
11



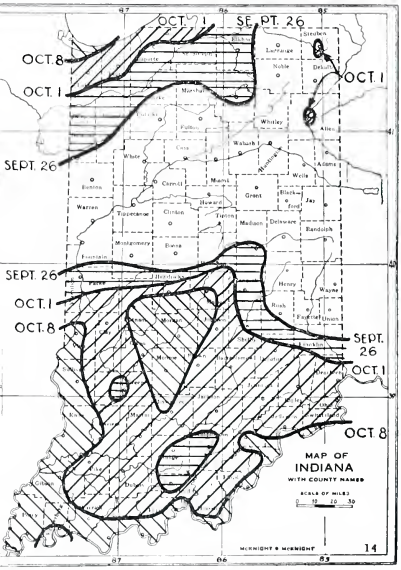
12

FIG. 11. Date of average first killing frost in autumn.

FIG. 12. Average length of growing season, between killing frosts.



13



14

FIG. 13. Last killing frost in spring in four out of five years. (In one-fifth of the years it is later than this.)

FIG. 14. First killing frost in autumn in four out of five years. (In one-fifth of the years it is earlier than this.)

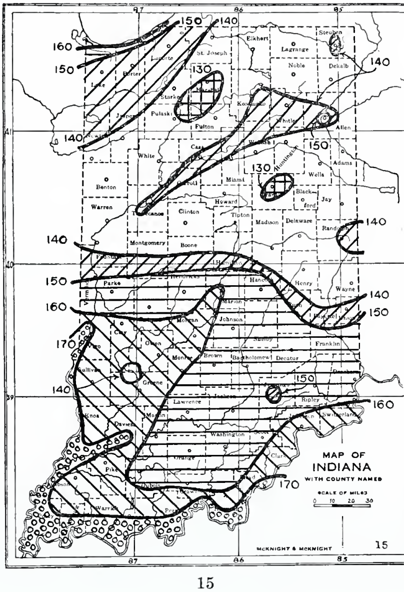
between these dates, or the average length of the growing season. In brief, in much of Indiana, killing frosts are to be expected during the last 10 days of April. The influence of elevation is strikingly illustrated by Figure 10, the elevated south central area having frost almost as late, on the average, as parts of north central Indiana. Indeed, northern Crawford County has its last frost in half of the years after April 28, while several northern stations fare distinctly better.

In the autumn the lower land along the upper Wabash River has a conspicuously later first frost than has adjacent higher land (Fig. 11), and, conversely, the high land of northern Crawford, Harrison, and Floyd counties has frost several days earlier than neighboring lower areas. For much of the state a killing frost may be expected within a few days of October 11.

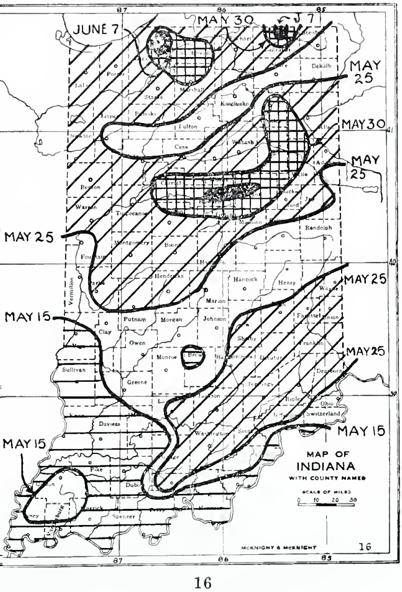
Figure 12, the average length of the growing season, shows that the contrasts are far less simple than they would be if latitude alone were responsible. The effect of Lake Michigan is conspicuous because near it the frost-free season is as long as in certain areas almost bordering the Ohio River.

Figures 13, 14, and 15 deal, not with the average year (half of the years), but with killing frost data in four-fifths of the years, in other words, with what can be conservatively expected a 4 to 1 chance, in contrast with the 50-50 chance dealt with in Figures 10, 11, and 12.

Figure 13 shows that for a considerable portion of the state killing frosts after about May 8 are relatively rare.



15



16

FIG. 15. Frost free period in four out of five years. (In one-fifth of the years it is shorter than this.)

FIG. 16. Latest killing frost in the spring ever officially recorded (to 1935).

Figure 14 shows that the first killing frost of autumn comes before October 8 in only one-fifth of the years in southwestern Indiana but before September 26 in a large part of northern Indiana. The exceptions in the latter area, Angola and Fort Wayne, which are also conspicuous on other temperature maps, reflect special local conditions. Angola is near Lake James, and Fort Wayne's weather bureau thermometers are on the roof of a high building, and in calm cold weather it often happens that temperatures are abnormally high on top of high buildings.

Figure 15, for the frost-free period,[4] shows, among other things, that the strip bordering Lake Michigan has almost as long a growing season as any section.

Record-Breaking Killing Frosts

Figures 16-19 deal with the record frosts—the latest and earliest officially recorded at about 90 stations. Killing frosts have been recorded after May 30 in considerable northern areas but not after May 15 in the south. For some reason, a sizable strip in northern Indiana never has, however, recorded frosts as late as adjacent areas. Indeed, this strip has fared better in this respect than has parts of southeastern Indiana.

Killing frosts have occurred in September in all parts of Indiana, before September in most of northern Indiana, and before September 10 in part of central Indiana. Again the effects of Lake Michigan and of the low elevations along the Ohio River are evident.

Figure 18 reveals the fact that much of southern Indiana has had years with only 130 to 141 consecutive frost-free days, while four scattered central northern areas have had less than 110 days, which period is too short for our corn.

The longest recorded growing season (Fig. 19) contrasts significantly with the shortest. All Indiana stations have had growing seasons of 177 or more days and little of the state has not had over 200 days. The southwestern counties and the Ohio River strip have had growing seasons long enough for successful cotton growing.

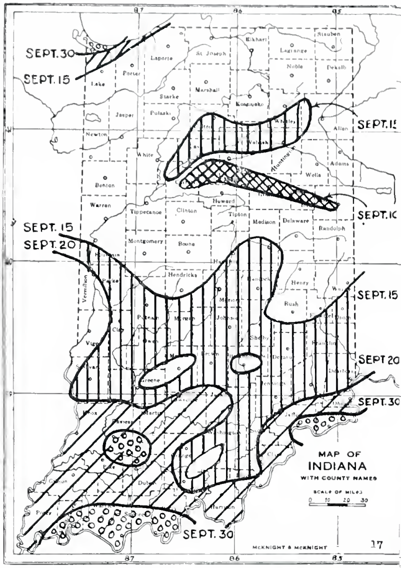
Some Effects of the Temperature Contrasts

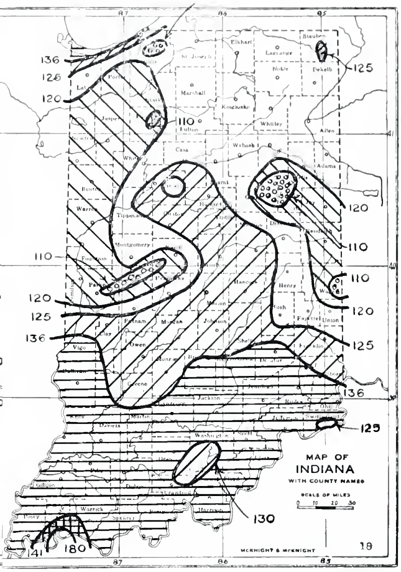
Indiana's contrasts in temperature affect appreciably several significant crops, farm practices, and biotic formations and many individual species. Their effects on man himself should not be ignored.

Because of the general suitability of Indiana's climate, the regional contrasts in temperature are less significant than are differences in relief and soil in explaining many of its contrasts in agriculture, flora, and fauna; nevertheless, a considerable number of correlations are evident. Some examples follow.

---

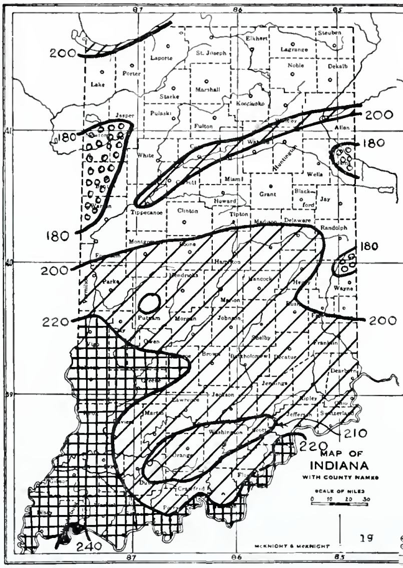
[4] Note that the length of the growing season here used is the period between the date of the last and first killing frosts in four-fifths of the years. This period is considerably shorter than the "growing season" in four years out of five as given in the tables in the climatic summaries published by the Weather Bureau in 1933. For southern Indiana many places have a conservative growing season about ten days shorter than one would expect by inspecting the lengths of the growing season of each of the years. The reason for this is that occasional years have abnormally early last frosts or late first frosts. In central and especially in northern Indiana there is, however, little discrepancy between Figure 15 and the map (not published) of the medium length of the frost-free season in four out of five of the years. This note is introduced as a warning to agriculturists to use the data of Figures 13, 14, and 15 rather than the mean of the lengths without regard to dates.

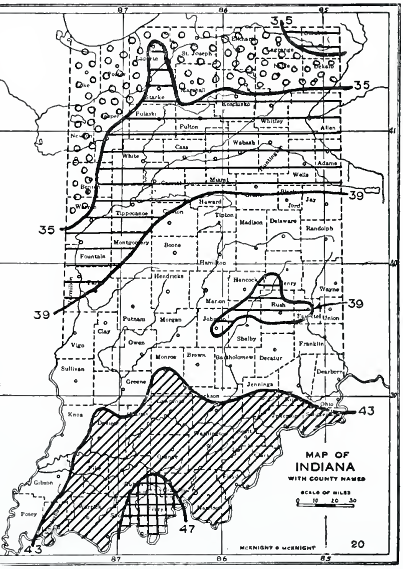




17 18

Fig. 17. Earliest killing frost in the autumn ever officially recorded (to 1935).
Fig. 18. Shortest growing season ever recorded.





19 20

Fig. 19. Longest growing season ever recorded.
Fig. 20. Annual precipitation in inches, average of all years to 1931.

1. Differences in length of growing season and duration of high temperature clearly affect the relative importance of corn as a crop. For most of the state temperature conditions are normally nearly ideal for corn, and this helps to explain the high rank that Indiana holds in corn production. Along the northern border, however, the period of high temperatures is often too short, with the result that corn is relatively less important there, and much of it is cut for fodder. Consequently the Corn Belt proper does not extend into the coolest part of the state, and is so delimited on recent maps issued by the U. S. Department of Agriculture.

2. Wheat, our crop next in importance, is likewise grown in all parts of the state because of the general excellence of the climatic conditions. But almost no spring wheat is grown, because the interval between sufficient drying out of the ground in spring and the coming of hot weather, which checks vegetative growth of wheat, is too short to permit a good yield. Winter wheat is harmed by heaving, during the frequent freezings of the top soil, but such damage is oftener overcome in southern Indiana than in northern because the period warm enough for wheat to grow but not hot enough to check growth is fully a month longer in southern than in northern Indiana. (As noted above the average daily temperature rises above 35° on February 16 along the southern margin of the state but not until a month later at the north; yet both north and south become too hot for wheat to grow vegetatively at almost the same date in June.) Partly as a result of this condition, wheat, which 50 years ago was most extensively grown along the northern border of the state, is now most extensively grown in southern Indiana, especially in the extreme southwestern part, the area with mildest winters.

3. Oats are grown widely also but most extensively in the northern part of the state, except the northern tier of counties. Oats are especially important in the western section which is slightly drier in winter and spring making it possible for the ground to be worked earlier and permitting a little longer vegetative growth before hot weather comes.

4. Fruits are cultivated in all parts of the state, but there is a conspicuous concentration of grapes near Lake Michigan with its notable effect in delaying autumn frosts. Strawberries are notably concentrated elsewhere in the northern section. Peaches, and to a lesser extent apples, are relatively abundant in the hilly southern section where slopes afford air drainage, which reduces damage from late spring frosts, and where subzero temperatures come less early in the winter and are less likely to damage buds.

5. Although watermelons and cantaloupes are grown locally in considerable amounts on sandy soils even in northern Indiana, the main concentrations of these crops are in almost the warmest part of the state, in the lower Wabash valley. There the last killing frost in spring comes earliest, as does hot weather. Hence the crop ripens some days earlier than elsewhere in Indiana or in higher latitudes or altitudes in other nearby states, and the crop brings a higher price.

6. The "southern" temperature conditions prevailing much of the year in the lowland of the southwest are more favorable for mules than for horses and help explain their relative abundance there.

7. Sheep are very much more plentiful in the northeastern coolest corner of the state than elsewhere, except in the relatively elevated, eastern counties south to Randolph. The only other county having half as many sheep per square mile as the five northeastern counties is Boone County, much of which is above 900 feet in elevation and has often a shorter growing season than surrounding counties.

8. The native flora and fauna are distributed in many instances in such a way as to indicate significant correlations with contrasts in temperature. There is time now for only a few examples. (The writer will appreciate being informed of additional correlations with the climatic maps.)

The cypress-tupelo-red gum forest extends northward into the lowest, warmest section in the southwestern corner of the state. The chestnut-chestnut oak-tulip forest extends northward into southern Indiana, and the line between it and the oak-hickory forest is at many points near various temperature lines shown on the above maps.

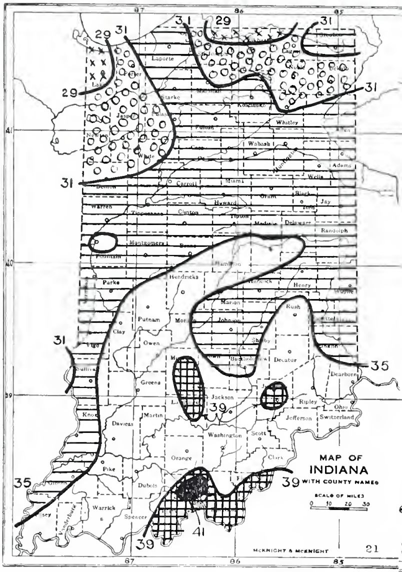
Many species characteristic of cooler regions reach their southern limit in northern Indiana, some of which like the badger, extend southward along the elevated, cooler eastern margin of the state to Randolph County. The Jack pine of the sand dunes, the tamarack, alder, and several other bogs species, the white cedar, paper birch, pin cherry, and balsam poplar are trees limited to the northern, cooler counties. Some trees limited as natives to the warmer southwestern part of the state are the pecan, overcup oak, catalpa, and persimmon.

9. Man himself also apparently reflects to some degree the contrasts in temperature conditions. The frequently observed greater energy and progressiveness in northern Indiana, as compared with southern Indiana, are presumably partly due to the fact that southern Indiana is much too hot for a distinctly longer period than is northern Indiana. Moreover, the summer heat is much more often broken by cooler periods in northern than in southern Indiana. This is because many of the highs and lows, which cause our change of weather, pass north of Indiana in summer, and their effects often scarcely reach southern Indiana. Although northern Indiana is more often too cold, mankind has been more successful in counteracting the effects of too low temperatures than in compensating for too high temperatures. Unquestionably northern Indiana's temperatures more closely approach, than do southern Indiana's, the optimum for civilized mankind, which is not over 65° F.

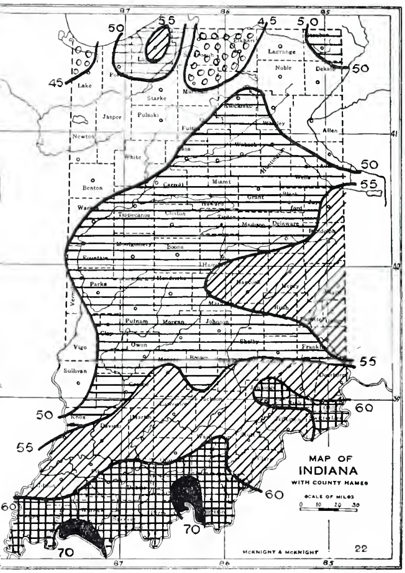
10. The striking regional contrasts on the death rates, discussed in the Proceedings for last year, also strongly suggest that regional contrasts in climate have a significant influence on disease and health in Indiana.

Precipitation

Annual precipitation: The average rainfall of Indiana (Fig. 20) decreases from the south northward in much the same way as the average temperature, but the explanation is very different. It is due to increased distance from the one important source of Indiana's rainfall, the Gulf of Mexico. The small influence of Lake Michigan upon Indiana rainfall is shown by the fact that the driest section of the state borders the lake and extends eastward therefrom. Most of the state normally receives



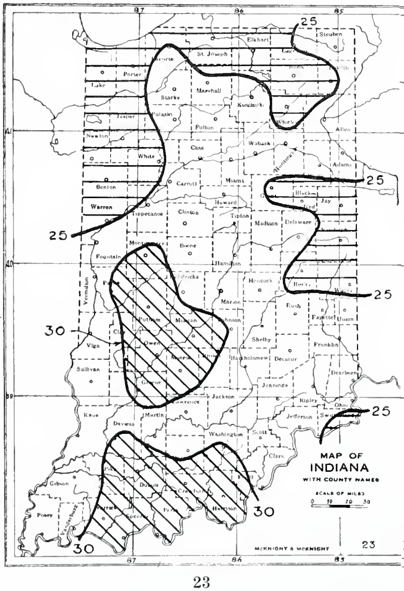
21



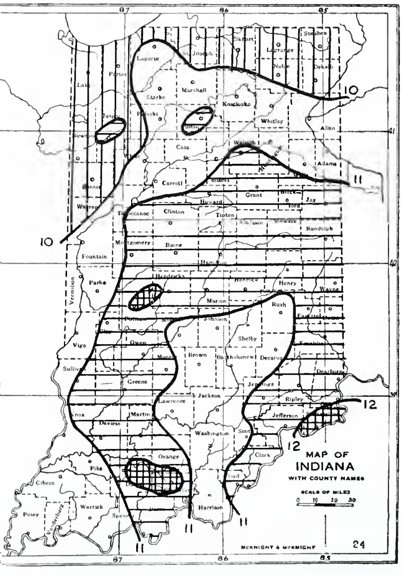
22

FIG. 21. Annual precipitation in four years out of five. (In one-fifth of the years it is less, in the other four it is this great or greater.)

FIG. 22. Heaviest precipitation ever officially recorded (to 1935 different years for different stations).



23



24

FIG. 23. Lowest precipitation, in inches. Record dry year for each station (different years for different stations).

FIG. 24. Average summer rainfall (total inches for June, July, and August).

within four inches of 39 inches of rainfall. The eastern half of the state receives more than the western half because the winds which bring the moisture from the Gulf spiral into the lows counter-clockwise, entering from the east, Moreover the lows move eastward rather rapidly, carrying with them some of the moist air.

Figure 21 is much more significant than Figure 20. It reveals that much of the state receives about 35 inches in four out of five years. Many stations of southern Indiana which receive over 43 inches in the average year (Fig. 20) receive less than 36 inches in four years out of five, or only six-sevenths as much, a much greater decline than is found in northern Indiana.

Figure 22 shows the greatest precipitation received in any year up to 1935 (different years for different stations). The state record (one of the highest reported by any station east of the Pacific coast) is 97 inches at Marengo, in 1890.

Figure 23 shows the precipitation totals for the driest year of record. Only eight out of 96 stations have received in their driest year more than 30 inches. Most of these eight received only 31 or 32 inches; indeed, no station with a long record has received over 33 in its driest year; nor has any received less than 22 inches except Valparaiso (18). Although nearly one-half of northern Indiana has received an inch or two less than 25 inches, much of the southern part has received only an inch or two more than 25 inches, a difference by no means sufficient to offset the greater evaporation due to the higher temperature of the south. In other words, much of southern Indiana during dry years is physiologically drier than northern Indiana. Excepting Valparaiso, the driest record for any station is Vevay on the Ohio River (22.5 inches in 1934).

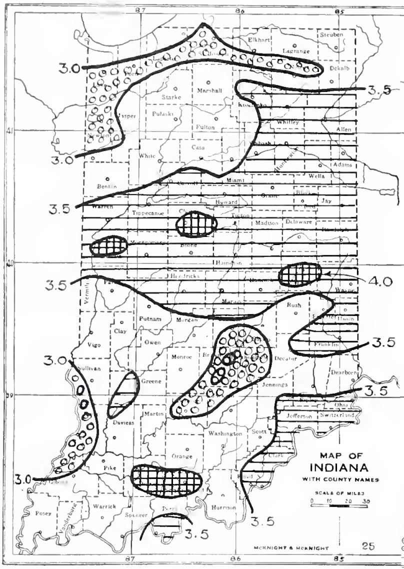
Seasonal Rainfall

Now let us turn to the rainfall of the warmer season, the rainfall that is especially important for plant growth.

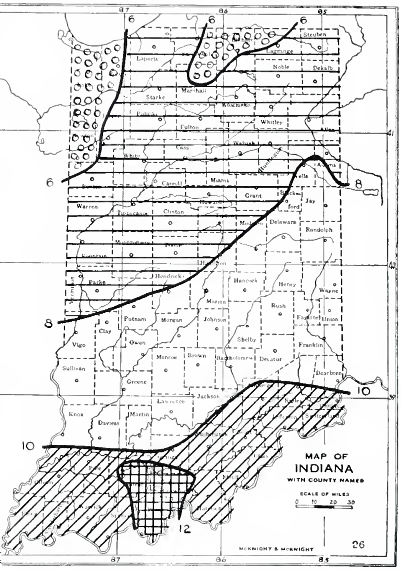
Figure 24 reveals that in summer (June, July, and August) most of the state receives approximately 11 inches of rain, and there is little difference between the northern and southern sections. Indeed, the area in south-central and southwestern Indiana which receives less than 11 inches is almost as large as the drier part of northern Indiana, and part of this southern area is distinctly drier than much of central Indiana. In other words, the higher average annual rainfall of the southern part of the state (Fig. 20) is not received in summer.

Maps of the average rainfall for each of the months April to August, inclusive, have been made, but only that for July is published here. The others, however, may advantageously be summarized. In April most of the state receives approximately 3.6 inches of rain; the northern third mostly receives a little less than 3.4 and the southern half mostly about 3.7. The rainiest extreme south-central section receives an average of 4.4 inches, but nearby southern stations receive as little as 3.6.

In May there is more rain on the average, much of the state receiving close to 4.1 inches. Of special interest is the fact that in May the



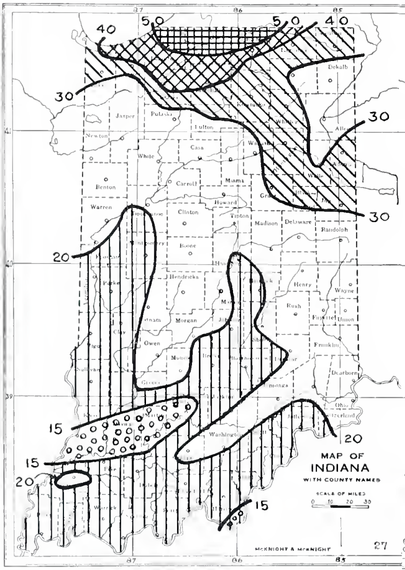
25



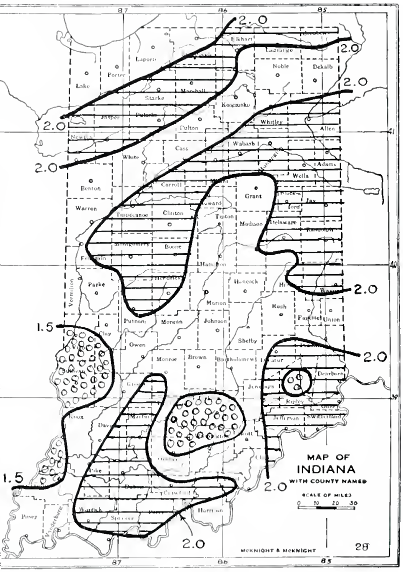
26

FIG. 25. Average July rainfall, in inches.

FIG. 26. Average winter precipitation (total inches for December, January, and February).



27



28

FIG. 27. Snowfall, annual average depth in inches.

FIG. 28. July rainfall in four out of five years. (In one-fifth the years less than this is received, in the other four, this much or more.)

west-central third normally receives most rain. Two of the three rainiest areas, receiving more than 4.7 inches, are in the northwest quarter.

In June most of the state receives about 3.8 inches, but three northern areas (at the northwest and northeast) receive slightly under 3.5, and three central and one large southern area receive between 4 and 4.7 inches. Two southern areas, however, receive less than 4.0 inches (in the south-central and southwestern sections).

July, perhaps the most critical month as far as rainfall is concerned, is especially interesting, and its average rainfall is depicted in Figure 25. The striking condition shown by this map is that most of southern Indiana receives one-fifth less rainfall in July than does central Indiana, and much of it receives less than northern Indiana. The amount received is, moreover, distinctly less than that of April, May, or June. As July is the hottest month, this lighter rainfall is unfortunate, and the southern section is especially handicapped.

In August all parts of the state share more equally, most stations receiving about 3.5 inches. Four small areas, two on the Ohio River and two on the northern boundary, receive less than three inches, and two small areas, one in the southwest and the other in the northwest, receive slightly over four.

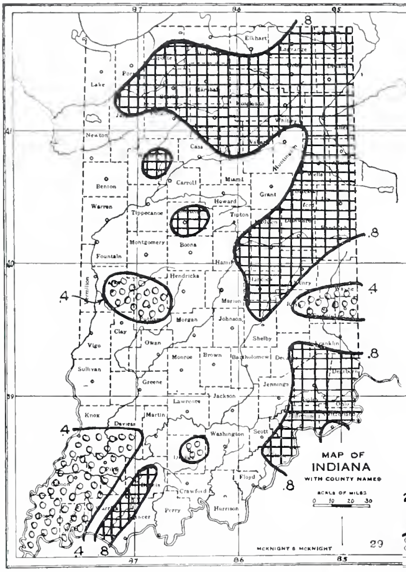
During the three autumn months most of Indiana receives between eight and ten inches, but a large southwestern area and a smaller southeastern one receive somewhat more than ten inches, while areas at the northwest and northeast receive somewhat less than eight inches.

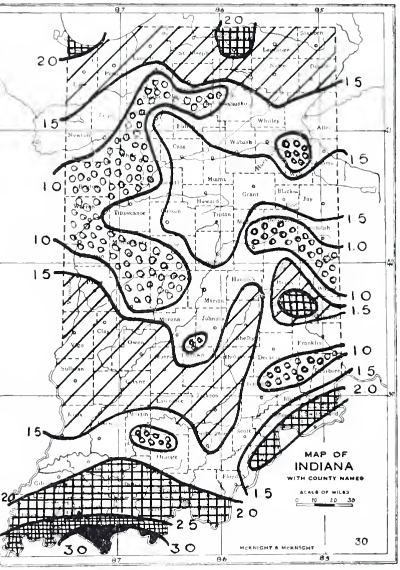
During the winter months (December, January, and February—Fig. 26) south-central Indiana, with over 12 inches, receives twice as much precipitation as the northwestern corner and an area surrounding Elkhart.

Figure 27 reveals that much of the state receives in an average year 20 to 30 inches of snowfall with an increase from southwest to northeast. The small area east of Lake Michigan receiving more than 50 inches indicates that, although the lake does not appreciably affect the rainfall, it does increase the snowfall. Winds which have blown across the lake in winter are chilled by the land, which is often then cooler than the lake, and sometimes are forced to yield snow. The Valparaiso moraine, just south of the end of Lake Michigan, also often receives several inches more snowfall than adjacent areas. The difference in duration of snow-cover corresponds roughly with the amount of snowfall, southern Indiana generally being snow-covered 10 to 20 days and northern Indiana 50 to 60 days.

Thus far we have considered under seasonal precipitation only the average conditions. Next it is desirable to consider the departures from normal. Figure 28 shows the July rainfall in four-fifths of the years. During one-fifth of the Julys less than those amounts are received and in the other four-fifths this amount or more. It shows that the driest one-fifth of the Julys receive less than two inches of rain in much of the state, and that southern Indiana fares worst.

Figure 29, the rainfall during the two driest Julys of record at each of the 70 stations, is highly significant. It reveals that at each station having records longer than ten years there have been two or more Julys when very small amounts were received. Since the mean length of the



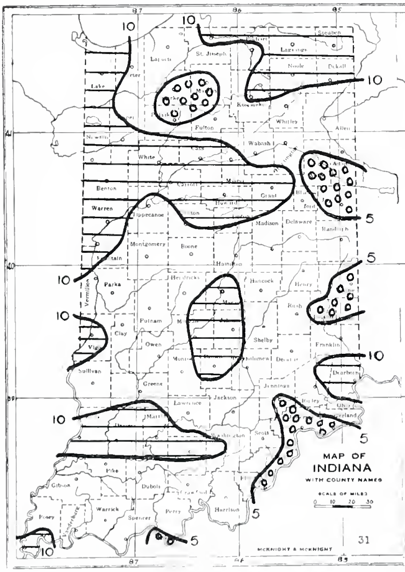


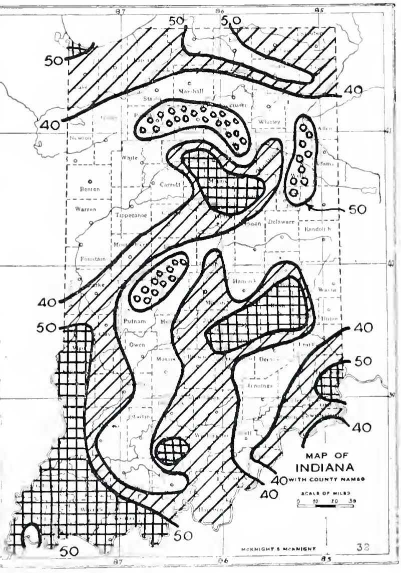
29

30

FIG. 29. July rainfall in the two driest Julys of record (median of the two), in tenths of an inch.

FIG. 30. Dry Augusts—percentage of the Augusts which have received less than 1.56 inches of rainfall.





31

32

FIG. 31. Dry Junes—percentage of the Junes which have received less than 1.56 inches of rainfall.

FIG. 32. Dry summer months—the sum of the percentages of Junes, Julys, and Augusts which have received less than 1.56 inches of rainfall (Figs. 30, 31, and an unpublished map).

records for these 70 stations is only about 25 years, this map indicates that one July in twelve or so is about this dry, much too dry for the best crop yields. These rainfall data indicate clearly that even in favored Indiana July is often too dry, and that the southern part of the state suffers more seriously from July drouth than do the central and northern parts of the state.

Next let us consider rainfall deficiencies in August. Instead of taking the two driest months of record, as was done for July, Figure 30 shows the percentage of the years when the August rainfall is less than 1.56 inches, or somewhat less than two-fifths of the normal. In as hot a month as August is in Indiana, 1.5 inches of rainfall means a serious drouth, with corn and other crops suffering seriously except where the soil is very retentive of moisture and has been well supplied with moisture late in July, or when the August rainfall happens to come almost ideally (as in three half-inch moderate rains on August 7, 15, and 23).

Figure 30 shows that a large share of west-central Indiana and a part of southeastern central Indiana do not have one August in an average decade that receives less than 1.5 inches of rain, but instead has one in from 11 to 15 years. Only three small areas in southern Indiana are that fortunate. Indeed, two considerable areas bordering the Ohio River receive less than 1.5 inches in more than one-fifth of their Augusts and one area has three Augusts out of ten which receive less than this amount. In the northern two-thirds of the state, however, only two stations, Hammond and Goshen, have had more than one-fifth of their Augusts this dry; they had one-fourth. Their temperatures in August average, however, 6° less than those along the Ohio River, which means that the average rate of evaporation is decidedly less. (The capacity of air for moisture doubles with a rise of 20° F., and, since 6° is nearly a third of 20°, nearly one-third more moisture is required normally to saturate the air in August near the Ohio River than at Goshen or Hammond.)

Maps corresponding to Figure 30 have been made for June and July. The one for July is not published here, because three maps of July rainfall are included (Figs. 25, 28, and 29). July is, however, such a critical month for our chief crop that the map showing the percentages of very dry Julys will be described. It shows that nearly all of the southwestern quarter of the state receives in July less than 1.56 inches of rainfall in one year out of five, on the average, and some parts of this quarter have had from 25% to 33% of their Julys this dry. On the other hand, only about one-tenth of the northern half of Indiana has had 20% of their Julys this dry. A large area in north-central and east-central Indiana has had fewer than ten percent of its Julys so dry that less than 1.56 inches of rain fell. Only one station (Bloomington) in the southern third of the state has been this fortunate.

June is sufficiently important for several crops that at least one map of its rainfall should be published. Figure 31 shows the percentage of Junes which have received less than 1.56 inches of rainfall. It is based on the 83 localities with a record of 14 years or more, 29 of which have records of 40 years or longer.

In June the average rainfall is, as already noted, greater than in July or August. Partly because of this, a smaller percentage of the

Junes have received less than 1.56 inches of rain. Few stations have had more than one-eighth of their Junes this dry, and for most of the state only five to ten percent are this dry.

The final map of this series (Fig. 32) considers June, July, and August and shows the sum of the percentages of these months which are very dry (receiving less than 1.56 inches of rain). Again the central part of the state with an average of 38 is seen to be distinctly more fortunate than the southern with an average of about 48. The southwestern section and most of the unglaciated, south-central region fare relatively poorly. No southern section is in the most fortunate division (less than 30%).

Causes of Rainfall Contrasts

Despite the northward decline in average annual rainfall, this study establishes that during dry years, during the average July, and during dry Junes, Julys, and Augusts, less rainfall is received in southern than in central Indiana. This northward increase is, of course, contrary to what has been assumed, on the basis of the annual averages.

It is due chiefly to the cooperation of two influences. The first is that a greater number of cyclonic disturbances or lows affect northern Indiana in summer. As already noted, the centers of many of the lows of summer pass to the north of Indiana, scarcely affecting southern Indiana. The lows cause much of our rainfall, partly by inducing convectional overturning or thunderstorms. Although, for the year as a whole, thunderstorms are more frequent in southern than northern Indiana, nevertheless in June, July, and August they are more frequent in the north than at the south. The regular weather bureau stations record, as accurately as they can, thunderstorm numbers, and that during each of the three summer months Royal Center has most thunderstorms and that in July Fort Wayne has as many as any other station, or more.

The second important cause of the frequently lower rainfall in summer in southern than in central Indiana lies in the fact that occasionally the high barometric pressures characteristic of a shifting belt often known as the High Pressure Calm Belt (which lies some 20 degrees on each side of the heat equator) reaches southern Indiana. This belt lies in summer across northern Africa in latitudes corresponding to southern Indiana. Wherever it is present, on sea or on land, drouths prevail and are broken only when some cyclonic disturbance temporarily overcomes the calm. This belt of calms very seldom extends north of latitude 40°, or central Indiana.

The local contrasts in rainfall revealed by many of the foregoing maps are due to two sorts of conditions, one more or less accidental and the other based on local differences in elevation, relief, and character of the surface as to moisture, vegetation, and soil. The more accidental influence is associated with irregularities in the course of cyclonic disturbances (lows) and their associated rains. In so far as these irregularities are accidental they tend to be equalized in time and hence disappear when a long enough record is available. Indeed, a number of striking irregularities shown by the average rainfall map of Indiana, issued in 1926 by the Weather Bureau, largely disappear when the fuller data now available are used, as has been done here.

The paths followed by thunderstorms are, however, frequently influenced by local surface conditions, and presumably some of the irregularities evident in the maps are related to elevation, relief, soil, etc. It is hoped that these maps will encourage studies of possible influences. (The author will appreciate evidence on these matters.)

Some Effects of Precipitation Contrasts

The precipitation contrasts in Indiana are of significance in more ways than can be pointed out here. A few, however, will be mentioned.

1. The heavy winter rains in the southern part of the state are important factors in causing extensive soil leaching and erosion there. Indeed, the ruggedness of much of southern Indiana is intimately associated with the heavy winter rainfall which much more often occurs in southern Indiana than elsewhere in the state.

2. The lower average crop yields (except on fertile almost flat river bottoms) in the south as compared with central Indiana are due, not only to differences in the soil and the people, but also partly to the more frequent deficiencies in rainfall in relation to temperature. Furthermore, because of greater ruggedness at the south, the runoff is greater than in central Indiana. In other words, more of the rainfall runs away without benefitting the crops, than does in central Indiana. Consequently the conspicuous contrasts in land values between southern and central Indiana are only partly the direct results of glaciation. The increased soil erosion is a factor, as are lower crop yields, associated partly with the frequently lower precipitation during the summer months, especially July.

3. Southern Indiana is not in the Corn Belt proper, as delimited in recent maps by the U. S. Department of Agriculture. Climatic basis for this is clearly evident in the low summer rainfall (Figs. 25, 28-32). Careful studies at the Experiment Station at the University of Illinois have established that corn should receive at least 2½ inches of rain a month during the three months of its chief growth. When more rain than this falls at the right time, the yield is much increased. For example, in eight years when a total of less than seven inches fell during the three months, June, July, and August, the average yield was 25.3 bushels per acre in an experimental plot. In the nine years when between 7 and 10 inches was received during three months, the average yield was 32.4 bushels per acre. In the eleven years when more than 10 inches fell, the average was more than 40 bushels. A yield of 100 bushels of corn per acre requires about 16 inches of rain, and, of course, rich soil, excellent seed, and good care.

The fact that in southern Indiana a large share of the Julys and Augusts receive less than 1.56 inches explains, therefore, the smaller average corn yields there.

4. The main area which was not forested was chiefly in the northwestern part of the state, in the section receiving less than 31 inches of precipitation in one-fifth of the years (Fig. 21). The northeastern dry area was forested, possibly partly because that area has much more snowfall. Small "prairies" along the western margin of southern Indiana, near Vincennes for example, were in the part of the state having

almost the least snowfall (Fig. 27) and also having more severe drouths than nearby forested areas. (Figs. 25, 28).

5. Rainfall is important not only for plants and animals but also for city water supply and factories. The relatively greater irregularity of rainfall in southern Indiana combines with higher temperatures and various other conditions to interfere with urban development. Except on large rivers, expensive reservoirs would be required to permit large cities to grow up there, and, because of greater erosion, such reservoirs would be filled with sediment relatively rapidly.

(It is my intention to present to the Academy next year additional regional contrasts, some local contrasts between nearby stations, and something as to variations from year to year, including possible secular changes. Suggestions will be appreciated.)

Conclusion

Despite Indiana's relatively small size and slight relief, there are significant contrasts in temperature and precipitation, and they have appreciable effects. The temperature contrasts are chiefly related to latitude, the southern part of the state normally being several degrees warmer than the northern part, especially in winter. Elevation also is significant, the most elevated sections of the state, at the east and northeast, usually being distinctly cooler than adjacent lower sections, and having a distinctly shorter frost-free season. The section of the state with highest average temperatures and longest growing season is the least elevated southwestern corner. Higher land east of there generally has a distinctly shorter growing season. At the extreme north, cooler temperatures interfere sufficiently with corn-growing so that northernmost Indiana is beyond the Corn Belt. Northern Indiana has, however, temperatures that are nearer the optimum for man than is true of southern Indiana, which is distinctly too warm during the summer. The influence of Lake Michigan in lessening severe cold and in prolonging the growing season is made strikingly evident by the temperature maps.

Annual average rainfall likewise decreases northward but as a result of increased distance from the one important source, the Gulf of Mexico. The northward average decrease is due, however, to the sharp decline in winter. During the summer, southern Indiana frequently receives somewhat less rainfall than central and northern Indiana. Moreover, the variations from year to year are greater at the south than farther north, and summer drouths are more frequent and serious there.

Regional contrasts in temperature affect the distribution of various crops, native trees, and animals, and also apparently affect human efficiency and progressiveness. Precipitation contrasts are clearly of significance with respect to the distribution of "prairies," corn yields, soil erosion, the value of agricultural land, and regional contrasts in suitability for urban development.

PROGRAM OF THE SECTION ON MATHEMATICS

Chairman: **Thomas E. Mason**, Purdue University

1. *House Bill No. 246, Indiana State Legislature, 1897. Will E. Edington, DePauw University.
2. Synthetic methods in differential geometry. J. H. Butchart, Butler University.
3. Some geometric applications of algebraic correspondences. C. G. Schilling, Purdue University.
4. A new approximation method for linear differential equations with rational coefficients. Cornelius Lanczos, Purdue University.

---

*Papers published in this volume.

HOUSE BILL NO. 246, INDIANA STATE LEGISLATURE, 1897

WILL E. EDINGTON, DePauw University

This paper has grown out of a number of requests for information over a number of years, by students and others, concerning some supposed action taken by the Indiana State Legislature with regard to fixing the value of *pi*, that is, the result of dividing the length of the circumference of a circle by the length of its diameter, at a certain value that was different from the true value. Of course the interest in and wonder at such an action lies in the presumption of a group of supposedly fairly well educated men to attempt to legislate upon something not in the realm of legislation.

The only reference to this action known to me until recently was an article by Professor C. A. Waldo in the Proceedings of the Academy for 1916. Professor Waldo was a member of the mathematics department at Purdue at the time the action was taken, but he was professor of mathematics at Washington University at St. Louis when he wrote the article. His article is merely a running account based on memory, and unfortunately there are several errors. The date of the action is given as 1899, and the description of the progress of the bill is inaccurate and somewhat misleading, as might be expected in a memory account written twenty years later, probably without any special check being made as to the facts. The error in the date caused me to spend many futile hours searching through the House and Senate Journals for 1899 for some record of the action.

However, during the past summer there appeared in the Contributors' Club of the July, 1935, number of The Atlantic Monthly an article by Professor Thomas F. Holgate, of Northwestern University, entitled "Rules for Making Pi Digestible", in which a statement of House Bill No. 246 was given, together with the correct date 1897. Armed with this information I have attempted to ascertain the facts as to the inception of the bill, its author, the history of the bill in the Legislature, and the atmosphere surrounding it during the successive steps of its progress through the legislative mill. The facts which I present here have been secured from the bill itself, on file in the Indiana State Library, the Journals of the House and Senate for 1897, and the files of the three Indianapolis papers for January and February, 1897. My purpose in presenting this paper is to have on record in an accessible place the facts concerning this most interesting piece of attempted legislation. The drawing of morals I leave to others.

The author of the bill was Edwin J. Goodwin, M. D., of Solitude, Posey County. The bill was introduced in the House by Mr. Taylor I. Record, Representative from Posey County, on January 18, 1897. In the Indiana Historical Library may be seen the handwritten copy together with a typewritten copy of the bill, and a handwritten record of actions taken by the Legislature. Some one has written on the page containing the record of the actions the following: "Dr. E. J. Goodman, No. 72 Ohio Street—Author". However, this is in error, for the author was Dr. E. J. Goodwin. Following is a copy of the bill:

HOUSE BILL NO. 246

A bill for an act introducing a new mathematical truth and offered as a contribution to education to be used only by the State of Indiana free of cost by paying any royalties whatever on the same, provided it is accepted and adopted by the official action of the legislature of 1897.

Section 1. Be it enacted by the General Assembly of the State of Indiana: It has been found that a circular area is to the square on a line equal to the quadrant of the circumference, as the area of an equilateral rectangle is to the square on one side. The diameter employed as the linear unit according to the present rule in computing the circle's area is entirely wrong, as it represents the circle's area one and one-fifth times the area of a square whose perimeter is equal to the circumference of the circle. This is because one-fifth of the diameter fails to be represented four times in the circle's circumference. For example: if we multiply the perimeter of a square by one-fourth of any line one-fifth greater than one side, we can in like manner make the square's area to appear one fifth greater than the fact, as is done by taking the diameter for the linear unit instead of the quadrant of the circle's circumference.

Section 2. It is impossible to compute the area of a circle on the diameter as the linear unit without tresspassing upon the area outside of the circle to the extent of including one-fifth more area than is contained within the circle's circumference, because the square on the diameter produces the side of a square which equals nine when the arc of ninety degrees equals eight. By taking the quadrant of the circle's circumference for the linear unit, we fulfill the requirements of both quadrature and rectification of the circle's circumference. Furthermore, it has revealed the ratio of the chord and arc of ninety degrees, which is as seven to eight, and also the ratio of the diagonal and one side of a square which is as ten to seven, disclosing the fourth important fact, that the ratio of the diameter and circumference is as five-fourths to four; and because of these facts and the futher fact that the rule in present use fails to work both ways mathematically, it should be discarded as wholly wanting and misleading in its practical applications.

Section 3. In further proof of the value of the author's proposed contribution to education, and offered as a gift to the State of Indiana, is the fact of his solutions of the trisection of the angle, duplication of the cube and quadrature of the circle having been already accepted as contributions to science by the American Mathematical Monthly, the leading exponent of mathematical thought in this country. And be it remembered that these noted problems had been long since given up by scientific bodies as unsolvable mysteries and above man's ability to comprehend.

Following the introduction of the bill it was referred to the House Committee on Canals. Just why it should be referred to this committee, frequently called the Committee on Swamp Lands, is difficult to understand. The following items appeared in the newspapers on January 19, 1897, under the heading of New House Bills:

> H.B. 246. By Mr. Ricard: Bill telling how to "square a circle". Swamp Lands.[1]
> Mr. Recard, H.B. 246—Bill telling how to "square a circle". Swamp Lands.[2]

On January 19, 1897, Representative M. B. Butler, of Steuben County, chairman of the Committee on Canals, submitted the following report:

> Your Committee on Canals, to which was referred House Bill No. 246, entitled a bill for an act entitled an act for the introduction of a mathematical truth, etc., has had the same under consideration and begs leave to report the same back to the House with the recommendation that said bill be referred to the Committee on Education.[3]

The bill was accordingly referred to the Committee on Education.

---

[1] The Indianapolis Journal, January 19, 1897, p. 3, col. 4.
[2] The Indianapolis Sentinel, January 19, 1897, p. 2, col. 3.
[3] House Journal, 1897, p. 213.

On January 20, 1897, the following appeared in The Indianapolis Sentinel:

> TO SQUARE THE CIRCLE
>
> Claims Made That This Old Problem Has Been Solved.
>
> The bill telling how to square a circle, introduced in the House by Mr. Record, is not intended to be a hoax. Mr. Record knows nothing of the bill with the exception that he introduced it by request of Dr. Edwin Goodwin of Posey County, who is the author of the demonstration. The latter and State Superintendent of Public Instruction Geeting believe that it is the long-sought solution of the problem, and they are seeking to have it adopted by the legislature. Dr. Goodwin, the author, is a mathematician of note. He has it copyrighted and his proposition is that if the legislature will indorse the solution he will allow the state to use the demonstration in its textbooks free of charge. The author is lobbying for the bill.[4]

The records concerning the bill in the Committee on Education, as given in the House Journal, are somewhat confused. In the Calendar of House Bills Introduced and Action Thereon, the record reads

> Referred back February 2 and
> Recommitted to the same committee
> Reported back February 4.[5]

In the House Journal proper, however, one finds under the date of February 2, 1897, that Representative S. E. Nicholson, of Howard County, chairman of the Committee on Education, reported to the House.

> Your Committee on Education, to which was referred House Bill No. 246, entitled a bill for an act entitled an act introducing a new mathematical truth, has had same under consideration, and begs leave to report the same back to the House with the recommendation that said bill do pass.[6]

The report was concurred in, and on February 5, 1897, it was brought up for the second reading, following which it was considered engrossed. Then "Mr. Nicholson moved that the constitutional rule requiring bills to be read on three days be suspended, that the bill may be read a third time now".[7] The constitutional rule was suspended by a vote of 72 to 0 and the bill was then read a third time. It was passed by a vote of 67 to 0, and the Clerk of the House was directed to inform the Senate of the passage of the bill.

After the bill had passed the House the Indianapolis papers reported on it as follows:

> NEW MATHEMATICAL TRUTH
>
> Mr. Record's bill "introducing a new mathematical truth", was passed under a suspension of the constitutional rule.[8]

> DR. GOODWIN'S THEAOREM
>
> Resolution Adopted by the House of Representatives.
>
> Following is the text of the resolution adopted by the House relative to the mathematical theorem of E. J. Goodwin, M.D., Solitude, Posey County. Whereas, it has been found (The remainder of Section 1 and all of Section 2 is printed).[9]

---

[4] The Indianapolis Sentinel, January 20, 1897, p. 5, col. 4.
[5] House Journal, 1897, Appendix, p. 183.
[6] House Journal, 1897, p. 489.
[7] House Journal, 1897, p. 588.
[8] The Indianapolis News, February 5, 1897, p. 2, col. 3.
[9] The Indianapolis News, February 6, 1897, p. 11, col. 4.

NO OPPOSITION TO IT

> The bill introduced by Mr. Record telling how to "square the circle" was unanimously passed by the house yesterday afternoon. It indorses a mathematical demonstration of which Dr. Edwin Goodwin of Posey County is author.[10]

MATHEMATICAL BILL PASSED

> Record's bill containing the discovery of Dr. Goodwin, of Posey County, for computing the area of a circle, was handed down upon second reading. Mr. Nicholson explained that Dr. Goodwin had a copyright on his discovery and had offered this bill in order that it might be free to the schools of Indiana. The bill was taken up and passed under suspension of rules. This is the strangest bill that has ever passed an Indiana Assembly. It reads as follows (The whole bill as given at the beginning of this paper is then printed).[11]

The contents of the bill thus became known in this and other states and, of course, became the target for ridicule. However, let us follow the progress of the bill.

Engrossed House Bill No. 246 was referred to the Senate on February 10, 1897, and was read for the first time on February 11 and referred to the Committee on Temperance. One wonders whether this was done intentionally, for certainly the bill could have been referred to no committee more appropriately named. On February 12 Senator Harry S. New, of Marion County, Chairman of the Committee on Temperance made the following report to the Senate:

> Your Committee on Temperance, to which was referred House Bill No. 246, introduced by Mr. Record, has had the same under consideration, and begs leave to report the same back to the Senate with the recommendation that said bill do pass.[12]

On the afternoon of February 12 "Senator Bozeman called up House Bill No. 246. The bill was read a second time by title. Senator Hogate moved to amend the bill by striking out the enacting clause. The motion was lost. Senator Hubbell moved to postpone the further consideration of this bill indefinitely. Which motion prevailed."[13]

This cold recital of Senate action gives no clue as to how these actions were taken but the reports in the papers do, as follows:

> House Bill 246, providing for the official adoption of the demonstration for squaring the circle, was killed.[14]

THE MATHEMATICAL BILL

> Fun Making in the Senate Yesterday Afternoon—* * *
>
> Representative Record's mathematical bill legalizing a formula for squaring the circle was brought up and made fun of. The Senators made bad puns about it, ridiculed it and laughed over it. The fun lasted half an hour. Senator Hubbell said that it was not meet for the Senate, which was costing the State $250 a day, to waste its time in such frivolity. He said that in reading the leading newspapers of Chicago and the East, he found that the Indiana State Legislature had laid itself open to ridicule by the action already taken on the bill. He thought consideration of such a proposition was not dignified or worthy of the Senate. He moved the indefinite postponement of the bill, and the motion carried.[15]

---

[10] The Indianapolis Sentinel, February 6, 1897, p. 2, col. 4.
[11] The Indianapolis Journal, February 6, 1897, p. 8, cols. 2, 3.
[12] Senate Journal, 1897, p. 649.
[13] Senate Journal, 1897, p. 677.
[14] The Indianapolis Sentinel, February 13, 1897, p. 2, col. 4.
[15] The Indianapolis News, February 13, 1897, p. 11, col. 3.

WORK OF THE SENATE

A lot of fun was had with Mr. Record's mathematical bill. It came from the House a few days ago and went to the committee on temperance. It was called up by Senator Bozeman. It was indefinitely postponed, as not being a subject for legislation. Senator Hubbell characterized the bill as utter folly. The Senate might as well try to legislate water to run up hill as to establish mathematical truth by law. Leading papers all over the country, he said, were ridiculing the Indiana Legislature. It was outrageous that the State of Indiana should pay $250 a day to have time wasted on such frivolous matters.

STRUCK A POPULAR CHORD

Senator Drummond did not want the rule suspended until he had some information as to the purpose of the bill.

"It may be I am densely ignorant on this question of Mathematics," he said. "Consent! Consent!" said Senator Ellison. There was loud laughter at this sally.

Although the bill was not acted on favorably no one who spoke against it intimated that there was anything wrong with the theories it advances. All of the senators who spoke on the bill admitted that they were ignorant of the merits of the proposition. It was simply regarded as not being a subject for legislation.[16]

Naturally the question arises as to what happened to bring about the defeat of this bill after it had passed the House, apparently had the backing of the State Superintendent of Education, was actively being lobbied for, and had passed the first reading in the Senate without comment. To answer this question one must read Professor Waldo's account.

As the session of the Legislature was drawing toward its close it chanced to be the duty of the writer to visit the State Capitol and make sure that the Academy appropriation was cared for. When admitted to the floor of the House, imagine his surprize when he discovered that he was in the midst of a debate upon a piece of mathematical legislation. An ex-teacher from the eastern part of the state was saying: "The case is perfectly simple. If we pass this bill which establishes a new and correct value for π, the author offers to our state without cost the use of his discovery and its free publication in our school text books, while everyone else must pay him a royalty." The roll was then called and the bill passed its third and final reading in the lower house. A member then showed the writer a copy of the bill just passed and asked him if he would like an introduction to the learned doctor, its author. He declined the courtesy with thanks remarking that he was acquainted with as many crazy people as he cared to know.

That evening the senators were properly coached and shortly thereafter as it came to its final reading in the upper house they threw out with much merriment the epoch making discovery of the Wise Man from the Pocket.[17]

---

[16] The Indianapolis Journal, February 13, 1897, p. 3, cols. 4, 5.

[17] Proceedings of the Indiana Academy of Science **1916**:445-446. 1917.

PROGRAM OF THE SECTION ON PHYSICS

Chairman: MASON E. HUFFORD, Indiana University

1. How to teach physics. R. B. Abbott, Purdue University.

2. Teaching algebraic signs in optics. R. B. Abbott, Purdue University.

3. *A unipolar magnetic compass. E. G. Plasterer, Huntington High School.

4. The consequences of the wave theory of light. Arthur L. Foley, Indiana University.

5. *The Hall effect in a circular bismuth plate. L. H. Peterson, Indiana University.

6. *The meaning and measurement of hardness. E. G. Mahin, University of Notre Dame.

7. A twenty-thousand volt D. C. plant with small ripple. W. I. Caldwell and J. E. McKinster, Purdue University.

8. Contact potentials at the surface—aqueous solution-air. K. Lark-Horovitz and J. E. Ferguson, Purdue University.

9. Scattering intensity of electrons as function of atomic number and electron energy. H. J. Yearian and J. D. Howe, Purdue University.

10. Mathematical expression of charge distribution in space lattice. Vivian Johnson, Purdue University.

11. Energy bands in metals. H. M. Krutter, Purdue University.

12. The structure of liquid potassium chloride. K. Lark-Horovitz and E. P. Miller, Purdue University.

13. Transition effect of cosmic ray showers. L. Nordheim, Purdue University.

14. The scattering of proton in hydrogen. R. D. Present, Purdue University.

15. Testing moving coil receivers. C. K. Stedman, Purdue University.

16. Simultaneous sets of fringes in a Michelson interferometer. I. Walerstein and R. A. Woodson, Purdue University.

17. *The response of photovoltaic cells to X-rays. A. J. Hiegel and E. W. Kenefake, University of Notre Dame.

18. A theory of the formation of boiler scale. J. F. Chittim, Purdue University.

19. The crystal detector as a rectifier of short waves. Mildred W. Bulliet, Indiana University.

20. *Experimental investigation of the crystal structure of solidified gases. E. E. Washer, Bureau of Standards, Washington, D. C.

21. Display of apparatus for spectroscopy and fluorescence demonstrations. R. D. Black, Wabash High School.

22. *The optical principles which are involved in the halo phenomena. Oliver E. Glenn, Lansdowne, Pennsylvania.

Papers 19, 20, 21, and 22 were read by title. No. 21 was illustrated with an exhibit. Title No. 22 was received too late to be included in the published program.

---

*Papers published in this volume.

A UNIPOLAR MAGNETIC COMPASS

E. G. Plasterer, Huntington High School

The purpose of this paper is to suggest the possibilities in the polar pivoting of magnets, which in the opinion of the writer greatly clarifies and simplifies the demonstration of the First and Second Law of Magnets.

By pivoting a magnetic needle at one of its poles, a unipolar magnetic compass is designed as shown in Fig. 1. Such a polar-pivoted needle can be used to demonstrate the law of magnetic attraction and repulsion. When a bar magnet is presented to the free end of the compass needle so that unlike poles are near, attraction takes place as indicated by the movement of the needle; or, when like poles are near, repulsion likewise takes place. The advantage of such a polar-pivoted needle is that when it is desired to demonstrate attraction, attraction alone can be demonstrated; and when it is desired to demonstrate repulsion, repulsion alone can be demonstrated, because the pole which is located at the pivot point has a zero lever arm and hence contributes nothing to the magnetic moment. In the case of the ordinary magnetic needle, which is pivoted between the poles, magnetic attraction or repulsion is always accompanied by repulsion or attraction, and these two effects form a couple which causes the needle to orient itself with respect to a magnetic field, a point that is not always obvious to the pupil.

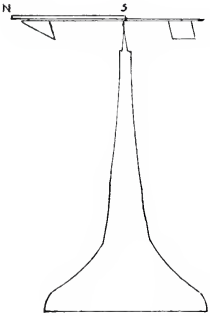


FIG. 1

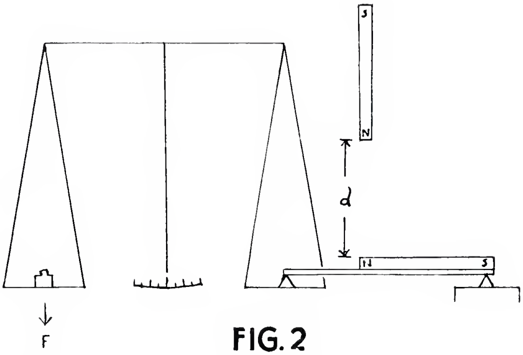


FIG. 2

A demonstration in either attraction or repulsion can be made conspicuously conservative by adjusting the magnetic needle so that both poles are on the same side of the pivot point and also in line with it. It can thus be shown, by presenting a magnetic field, that the predominant movement of the needle takes place as a result of the moment of the pole at the greater distance from the pivot, while the other pole, which has the shorter lever arm, tends to produce motion in an opposite direction, as indicated by bringing a bar magnet very near it, which then produces motion in the opposite direction. Thus attraction can be demonstrated in spite of repulsion, and repulsion can be demonstrated in spite of attraction, a point that will surely be obvious to the pupil.

The apparatus used in the demonstration for this paper was constructed for the writer by Mr. Robert Rice. It consists of a ten-inch aluminum bar which carries a bar magnet made from a clock spring. The magnet is adjustable so that it can be extended along the aluminum bar, making it possible to place it in any desired location with respect to the pivot point. A slide-adjustable copper weight counterbalances the system. A twelve-inch pedestal bearing a needle point furnishes the base for the aluminum bar. Various sized apparatus were made, giving in each case the same results.

In order to test the possibilities of using the polar-pivoted magnet in the demonstration of the Second Law of Magnets, which states that the force of attraction or repulsion between two poles varies inversely as the square of the distance between the poles, several hookups were used. The simplest and most satisfactory was to place a six-inch magnet upon a ten-inch hardwood bar, which was supported at either end by knife-edge supports such that one pole (South) of the magnet rested over one knife-edge support, while the other end of the bar extended and rested upon the knife-edge which was supported by one pan of a chemical balance. Above the free pole (North) of the magnet, and at right angles to it, was placed vertically, at measured distances, another magnet which produced the repulsing force. The relative forces were measured by the balance, while the distances between the poles were measured by a meter stick. Fig. 2 shows a schematic drawing of the assembly.

One apparent advantage in this set-up is that the earth's field produces no effect that can vary the readings, as the position of the polar-pivoted magnet never changes. For a practical demonstration the writer believes that it may be assumed without too much error that the upper or far-away pole of the vertical magnet has no effect upon the readings.

The following data are here submitted showing a high school student's results, using the above described set-up of apparatus:

F equals the relative chemical balance readings.

d equals the distance between like poles in cm.

Fd^2 should be a constant if our data have any significance in proving the law of inverse squares for magnets.

d (cm.)	F (g.)	Fd^2
24	.012	6.912
20	.019	7.600
18	.023	7.452
16	.033	8.488
15	.032	7.200
12	.059	8.496
10	.085	8.500
8	.131	8.384
6	.215	7.740

In submitting this sample of the various data taken, there is no intention of making claims, but rather to suggest possibilities of interesting research with polar-pivoted magnets.

THE HALL EFFECT IN A CIRCULAR BISMUTH PLATE[1]

L. Howard Petersen, Indiana University

Volterra (1), from theoretical considerations developed a Principle of Reciprocity, as he called it, for the Hall effect in a circular plate. Alimenti (2, 3) extended Volterra's Principle of Reciprocity and measured the Hall effect in a circular plate when the current entered and left by means of point electrodes situated at the mid-points of perpendicular radii. He found four points on the plate where the potential difference, between these points taken by twos in all combinations, is the same when the magnetic field is excited. As the author was investigating the Hall effect in rectangular plates of bismuth (4) and had the necessary apparatus for making a circular plate, it was decided to verify Alimenti's experiments. Accordingly a bismuth plate 4.7 centimeters in diameter and .088 centimeters thick was made for the experiment.

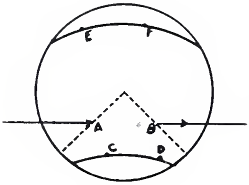


Fig. 1.

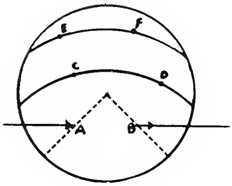


Fig. 2.

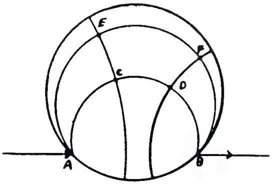


Fig. 3.

The current entered and left the plate by means of the point electrodes A, B, Figure 1, which are situated on the midpoints of perpendicular radii. The points E, F, and C, D, are generic points situated on two curves both belonging to the reciprocal points of A, B. According to Alimenti, the difference of potential between the points E, F, C, D, taken two at a time, should be equal when the plate is acted upon by a magnetic field. Table I gives the difference in potential in micro-volts between the above named points using two amperes through the plate and acted upon by a field intensity of 6100 gauss.

TABLE I

Between Points	H(off)	H(on)	H (reversed)
CD	1276	1578	1510
CE	284	489	149
CF	660	930	628
DF	620	645	880
ED	989	1077	1347
EF	371	436	476

---

[1] Part of the thesis submitted to the faculty and trustees of Indiana University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

TABLE II

Points	Current Flow A to B			Current Flow B to A		
	H(off)	H(on)	(reversed)	H(off)	H(on)	H(reversed)
ED.....	955	1175	1303	983	1246	1298
CD.....	1155	1465	1520	1113	1454	1442
FD.....	548	688	762	576	743	775
EF.....	423	505	550	404	503	510
EC.....	198	274	217	133	214	162
CF.....	616	774	757	539	724	673

TABLE III

Points	Current Flow A to B			
	H(off)	H(on)	H (reversed)	Average With H(on) and H (reversed)
EF..................	1245	1541	1663	1602
CF..................	1245	1568	1633	1601
CD..................	1245	1565	1623	1594
ED..................	1241	1539	1652	1596
EC..................	0	26	–26	26
FD..................	0	10.5	0	5.25

Points	Current B to A			
	H(off)	H(on)	H (reversed)	Average With H(on) and H (reversed)
EF..................	1287	1698	1560	1629
CF..................	1299	1744	1567	1655
CD..................	1299	1721	1580	1650
ED..................	1285	1677	1571	1624
EC..................	0	–18	17	17.5
FD..................	0	–4	19	11.5

Table I, which is representative of several sets of data taken with the point electrodes situated as shown, indicates that the writer was unable to find any four points on the plate, between which the differences of potentials are the same under the influence of a magnetic field.

The points C, D, were moved to another arc of a circle belonging to the reciprocal points A, B, as shown in Figure 2. The difference of potential in micro-volts was recorded as shown in Table II, when two amperes flowed through the plate and under the influence of a field intensity of 6300 gauss.

The table, which is representative of several sets of data, shows that the writer was unable to find four points on the plate where the difference of potential was equal.

When the current-carrying electrodes are placed on the circumference of the plate, a special case is encounterd, which is calld the theorem of four vertices of Professor Volterra, who says:

"When the point electrodes are on the circumference of the plate, if one considers the quadrilateral formed by the lines of current and corresponding level lines in the case in the magnetic field, and if one determines the value of the electric potential at the four vertices when acted upon by the magnetic field, the difference of the value of two adjacent vertices is equal to the difference between the other two."

With the point electrodes situated as shown in Figure 3, the differences of potential in micro-volts were recorded in Table III, when a current of two amperes flowed and under the influence of a field intensity of 6060 gauss.

In Table III the differences of potential between adjacent points are not exactly equal in all cases, but the differences are so small that they can be attributed to experimental error. Thus the theorem of four vertices is confirmed.

In conclusion, I wish to thank Dr. A. L. Foley, who suggested this problem, and the other members of the faculty of the Department of Physics, for their many helpful suggestions and encouraging attitude during the various phases of this experiment.

References

1. Volterra, V., 1915. Nuov. Cim. **9**:23.
2. Alimenti, A., 1915. Nuov. Cim. **9**:109.
3. Alimenti, A., 1916. Nuov. Cim. **11**:217.
4. Petersen, H., 1934. Proc. Ind. Acad. Sci. **43**:185.

THE MEANING AND THE MEASUREMENT OF HARDNESS

By E. G. Mahin, University of Notre Dame

Hardness, as the term is ordinarily used, implies resistance to penetration, scratching, or wear. From a somewhat more general view one would define hardness as resistance to permanent deformation under any kind of stress, with the single qualification that this stress is applied through steady loading, thus excluding impact.

It would appear, therefore, that the measurement of the hardness of any given material would be a comparatively simple matter, involving merely the use of a mechanically suitable testing machine, with load, penetrator, and method for calculating and reporting, standardized. In metallurgy it is a well recognized principle that hardness, as determined by almost any standard method, is, in at least an approximate measure, proportional to mechanical strength. This would naturally follow from the above general definition which, in turn, rests upon the equally well recognized principle that, no matter how static deforming stresses are applied, yield to these stresses involves the same fundamental effect—translational slip within the crystalline grains of the metal. The case is not so simple, because metals and their alloys present the interesting and unique anomaly of becoming harder—and therefore stronger—as a result of strain. In other words, when a metal is subjected to plastic deformation it becomes harder and stronger than before, as measured by its resistance to further deformation under stress. The strength of all metals is increased by strain, although to different degrees.

It would not be profitable here to go into a detailed discussion of accepted explanations for this phenomenon, but the fact is well known and frequently utilized for improving strength characteristics of metals and alloys. From this arises the question: Is hardness to be understood as a measure of resistance to *any* permanent deformation, however small, or of the ability of the metal finally to *stop* deformation. If the latter (and this is the only significance of the term, as applied to any existing methods for measurement) then it should be noted that we are actually determining the "hardness" of strain-hardened material and not that of the original unstrained metal, as it is when it goes into service. If the former, then at present we have no standard method for determining hardness, since it is obviously necessary to penetrate, scratch, or otherwise deform in order to note the effect of the application of the stress which causes this deformation.

In this connection it seems not necessary to go into a detailed discussion of the various hardness testing methods or of standard testing machines, although it may be useful to classify some of the better known as to type, limiting this to static loading methods, since impact "hardness" tests bring into play various other qualities, such as ultimate strength, ductility and resiliency. Testing methods involving penetration under steady loading include the Brinell, Vickers, Rockwell, Monotron, Firth Hardometer, and numerous other less used testers. The only scratch tester that has been refined to the point of quantitative usefulness is the Microcharacter, as perfected by Bierbaum. Wear hardness tests are so varied in nature and so uncertain in results that they cannot be regarded as better than empirical tests, sometimes useful but not susceptible to very scientific interpretation.

Absolute Hardness.—This term is used to designate the maximum unit stress which a metal will support, as applied through a loaded penetrator, without suffering any permanent deformation. Considering this along with conventional hardness numbers, there is shown a sort of analogy with limit of elasticity and ultimate strength in compression. It is generally recognized by engineers that in compression, tension, torsion, or bending, the limit of elasticity is a more useful figure than is the ultimate strength, for two reasons: (1) correct design must preclude the possibility of any permanent deformation whatever, in service; (2) ultimate strength is, like conventional hardness numbers, a measure of the strength of strain-hardened material.

There is on record a report of only one attempt to determine absolute hardness by "strainless indentation." Harris[1] proceeded by first applying the conventional Brinell test, then annealing in a non-oxidizing atmosphere to remove the effects of strain-hardening. Upon reapplying the load to the Brinell ball in the impression already made, the ball, of course, increased the depth of penetration. The annealing and application of the load were repeated until it was found that no further penetration occurred. The final maximum diameter of the impression and the load employed were used in the calculation of the absolute hardness of unstrained material.

The Harris "absolute hardness" cannot be an ideal representation of the hardness of the original unstrained material, for two reasons: 1. It is obvious that each application of the load after annealing would cause a certain additional straining—therefore hardening—of the metal. This effect would diminish with each successive test but it could never reach a value of zero but only approach zero as a limit, and this after an indefinitely large number of tests. 2. It is well known that annealing after strain produces grain refinement and that grain refinement increases hardness.

Method Used in the Present Investigation.—We have attempted to avoid these complications by producing a "Brinell" impression by mechanical removal of metal, rather than by inducing plastic flow, as is the case with the Brinell and all other existing hardness tests. For the softer metals and alloys a special drill was used. This is a two-fluted drill, ground to spherical curvature and with a radius of five millimeters, thus giving a depression of the same form as that of the Brinell ball, but with no strain-hardening effects except those produced by the drilling operation, limited to an extremely shallow layer at the surface of the depression. A special precision measuring microscope was used for measuring the diameter of the impressions. This microscope is provided with cross hairs, thus eliminating the errors of parallax, and measurements may be made with a precision of ±0.002 millimeter.

The procedure is, of course, rather tedious. A conventional Brinell test is first made, to serve as an approximate indication as to the depth of drilling that will be required. A series of depressions is then made by means of the special drill, testing after each is finished, until a depth is found such that the Brinell ball, under the selected load, just fails to widen the impression. The measured diameter of this is used in calculating the absolute hardness of the metal.

---

[1] J. Inst. of Metals, 2:327. 1922.

A few of the many results obtained in this test are given as illustrations of the general relations that are found to exist between absolute and Brinell hardness. There is no exception to the general rule that absolute hardness is very much lower than conventional hardness numbers. Tests upon five classes of materials are shown in Table I.

TABLE I

COMPARISON OF BRINELL AND ABSOLUTE HARDNESS

Material	Brinell Number	Absolute Hardness
Nickel steel	163	113
Tool steel, S. A. E. 1095	170	110
Tool steel, S. A. E. 1125	174	114
Swedish iron	83	47
Bronze	56	31

Discussion.—All of these hardness numbers are calculated as unit stress, in kilograms per square millimeter. It was recognized by Brinell that his formula, involving as it does the spherical surface of the impression, is mathematically incorrect since the true supporting surface is the circular projection of the impression, rather than its spherical surface. This gives a somewhat lower hardness number but is the method which is practically universally used. In calculating the present absolute hardness numbers the circular, rather than the spherical, area has been used.

From the few determinations reported above it is seen that, although there is a marked difference between the hardness numbers of the two types, absolute hardness always being much lower than conventional hardness, no constant relation exists between the two. This is the expected result, considering the fact that the various metals and alloys differ to a large degree in their capacity for work-hardening. As a result of the accumulation of many more data it is hoped that some formula may be derived for calculating the work-hardening capacity in terms of the two hardness numbers. Such a formula must necessarily be somewhat empirical, but it should be a useful addition to our repertoire of testing methods.

Experimental investigations are now being pursued in the field of age-hardening alloys, as typified by Duralumin and copper-beryllium. Some results have already been obtained which are somewhat startling in nature. A report upon these has not yet been made and they are here mentioned merely to indicate the general field covered by the investigation.

THE RESPONSE OF THE WESTON PHOTRONIC CELL TO X-RAYS

A. J. Hiegel and E. W. Kenefake, University of Notre Dame

It has been found independently by us, Paul R. Gleason[1], of Colgate University, and others[2] that photovoltaic cells respond to x-rays in much the same way as they do to light.

A thorough study of the properties of the Weston Photronic cell was therefore undertaken with the idea of determining its advantages and limitations for routine intensity measurements such as occur in an x-ray laboratory. To prepare these cells for use with x-rays, several layers of thick black paper were substituted for the glass front of the cells. Tubes with tungsten and molybdenum targets were used as the sources of x-rays, and the current output of the cells was measured with a galvanometer of 505 ohms resistance and a sensitivity of 10^{-10} amperes per millimeter. The cell's response at different wave lengths was compared with a standard ionization chamber operated with a potential of 1450 volts.

In accordance with Gleason's results, the cell's response was not found to be proportional to that of the ionization chamber, the cells being relatively more sensitive at shorter wave lengths. The current per "e" unit was determined as 1.7 microamperes as compared with Gleason's value of 1.2. Cells giving the same response to light do not necessarily respond the same to x-rays. Variations of as much as 50 per cent were found among the cells used. However, individual cells give constant results over a period of weeks. Special shielding of cells and connections against electrostatic surges, which was done by Gleason to prevent breakdown of contacts at the thin metallic electrodes, proved unnecessary if the x-ray tube was not operated above 120 kv. and the cells were kept at a distance of more than 18 inches from the tube.

A certain time lag in the response of the cell to incident x-rays exists. The time of this lag is of the order of 20 seconds. The final output, however, remains constant for an indefinite time. This may be compared to a very much shorter time lag which is observed in the response of the cell to visible light.

There was also a decided dark current evidenced by the slow return of the galvanometer to zero. The maximum magnitude of this dark current is roughly independent of the intensity, but the total duration of the current increases with intensity. After an intensity of 0.03 "e" units has been falling on the cell, the dark current falls to about 10 per cent of its original value in 10 minutes. Under these same conditions the magnitude of the dark current is roughly 10 per cent of the current given by the cell when activated by x-rays. The final reading of the galvanometer, however, is not affected by the dark current. This means that, once the zero position of the galvanometer has been determined when there is no dark current, the final reading of the galvanometer is a true measure of the x-ray intensity.

Upon subjecting the cells to different temperatures, their reaction was found to depend on the temperature. An increase in temperature produces a decrease in response. The rate of decrease in response is less at higher temperatures than at low. This characteristic was investigated over a range of 50°C. around room temperature. For an increase of 20°C. above room temperature the decrease in response was about 15 per cent, while for a decrease of 10°C. below room temperature the increase in response was about 50 per cent.

---

[1] Gleason, 1933. Phys. Rev. 43:775A. Gleason, 1933. Phys. Rev. 44:330A.
[2] Zeits. f. Physik 80:465. 1933.

The current output of these cells is much smaller for x-rays than for light. This is due to the fact that a large proportion of the x-rays pass through the blocking layer without being absorbed. For usual x-ray intensities a galvanometer of 10^{-9} amperes per millimeter deflection is required as compared to a microammeter for light.

The cell's response is almost linear to x-rays of moderate intensity provided the cell works into an external resistance of about 500 ohms or less. When larger external resistances are used the response becomes proportionately less with increasing intensity. This is strikingly similar to the linearity of the cell to light intensities when different external resistances are used. As in the case of light, the linearity is increased by decreasing the external resistance. Good results have been obtained with large intensities which permitted the use of a galvanometer of low resistance. With low intensities, however, it is necessary to use a galvanometer of high resistance, which causes the response to be nonlinear.

The advantages of the cell in measuring x-ray intensities are its large current output as compared to the ionization chamber and the fact that no external potential is required. The disadvantages of the cell are its slow response, dark current, and temperature effect. The latter is the only one of importance, and that is practically eliminated if the cell is used in a laboratory where the temperature is fairly constant. These results indicate that if the temperature is kept fairly constant the Weston Photronic Cell is well adapted for the measuring of relative x-ray intensities when absolute intensity is not important.

CRYSTAL STRUCTURE OF SOLIDIFIED GASES

FRANCIS E. WASHER*, Purdue University

The crystal structures of substances existing at ordinary temperatures in the gaseous or liquid state is of great interest because of the possibility of obtaining some information regarding the molecular structure. The investigation of crystal structure, if carried out completely, leads to information on the exact positions of the atoms with respect to one another and gives, therefore, direct information regarding the binding forces. By comparing the molecular arrangement for different states it is possible to determine the change of valence angle and of atomic distance and, consequently, of the free energy.

We have investigated carbon disulfide to compare its structure with the structure of carbon dioxide, which shows a completely symmetrical molecule, viz., a carbon atom in the center of the straight line joining the oxygen atoms, and the whole system in a cubic arrangement. Both carbon and sulphur belong to the same group in the periodic table and have the same distribution of outer electrons, but the polarizability is different.

We have investigated acetylene (C_2H_2) and ethylene (C_2H_4), since in this way one can obtain information regarding the arrangement of the triple and double bound carbon atoms. Moreover, the optical investigation of Wahl[1] seems to indicate that acetylene has a simple structure near its sublimation point, and it was, therefore, considered possible that even at —185° (liquid air temperature) this structure would be only slightly distorted.

Experimental Procedure

Two different methods have been used to obtain diffraction patterns from the solidified gases. The first method adapted to low temperature work, by K. Lark-Horovitz[2], consists of an arrangement in which slit, crystals, and photographic film are placed on the circumference of the same cylinder. Focusing of the diffracted beam is obtained in this way, and, since a large amount of crystal material reflects, the time of exposure is shortened. In this device the gas is solidified on the carefully ground bottom part of a liquid air container held in the vacuum camera by a ground joint so as to avoid contamination by grease vapor. This ground joint is developed according to Siegbahn[3], the camera being protected by a rectangular groove in the wall, this groove being evacuated through an auxiliary tube. This focusing method gives twice the resolution of the ordinary powder camera but has the disadvantage of cutting out reflections at small angles which are particularly important for the interpretation of complicated structures.

For this reason another camera has been used, in which the gas is condensed on a metallic capillary tube or a wire which is carefully centered, and in this way the small angles of diffraction are obtained. Since most of the gases used are of low molecular weight as compared with the metal capillary, standard lines from the metal are produced on the film for measurement.

---

*Now with Division of Optics, Bureau of Standards, Washington, D. C.

[1] Proc. Roy. Soc. London A89:327. 1913.

[2] K. Lark-Horovitz, 1925. Science 64:303.

[3] Spectroscopy of X-rays, p. 61.

The camera is pumped down to a good vacuum. The liquid air container is then filled with liquid air, and, if there are no impurities present, the metal will remain clean, and no solid deposit of foreign gases will be produced on it. The gases to be investigated are carefully purified and admitted in small quantities to the camera. A solidified deposit of the gas to be investigated is then formed on the metal and continued until a uniform coating has been obtained. X-rays produced in a special high power tube developed in this laboratory[4] enter through the aluminum window and are diffracted from the crystallites. The $K\alpha$ radiation of chromium, iron, and copper has been used. In most cases filtered radiation was applied. Recently some experiments have been carried out with strictly monochromatic radiation so as to make it possible to apply Fourier analysis to the diffraction pattern.

For the purification of the carbon disulfide, a process described by Obach[5] has been used. By this process water and any residue containing free sulphurated hydrogen or other decomposition products are removed. The product was repeatedly distilled, and the final substance investigated

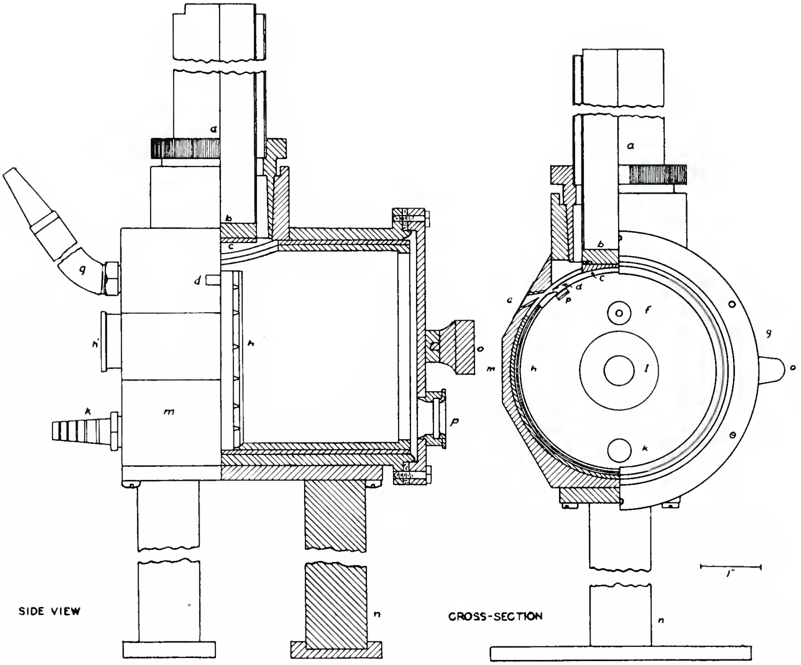


FIG. 1. Focusing low temperature X-ray camera. Side view and cross-section showing Dewar flask *a* with copper bottom *b*; crystal face *c*, (made of aluminum block to minimize background due to scattering), film holder *h* and gold slit *d* (0.001" wide) being on the same circumference; *p* is an additional inner shield to cut out radiation scattered from the slit. The front plate carries a window *P* for observation of the crystal formation. Evacuation is effected through tube *k*, while gas can be admitted through *g*.

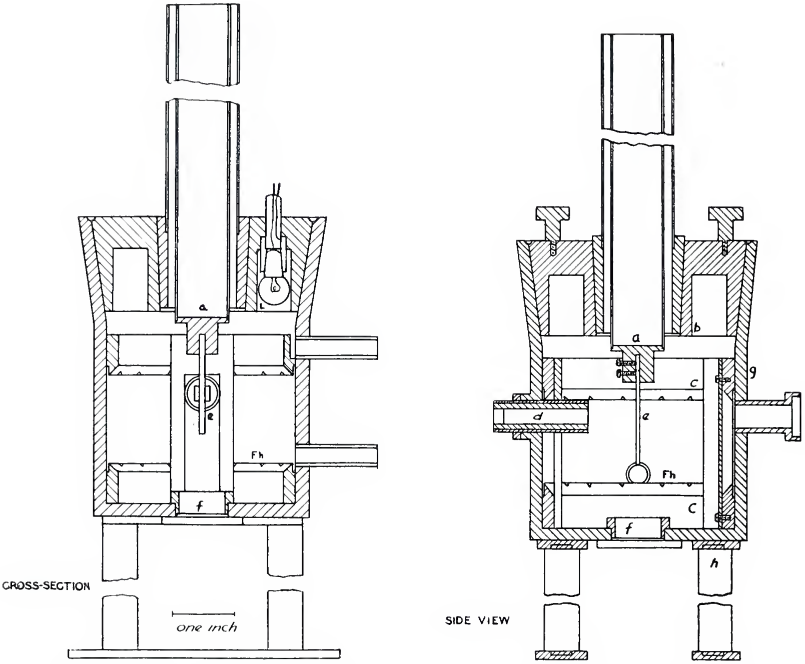


FIG. 2. Low temperature powder camera, cross-section and side view. Dewar flask *a* carries capillary *e* through which liquid air can stream and then return through a different capillary back into the container, thus securing equal temperature over the whole length of the capillary. Filmholder *h* showing triangular cuts to give standard mark on the film. Capillary *e* can be replaced by a silver wire or other type of specimen holders. Observation can be made through window *f* by using a mirror, the sample being illuminated by light from top of the camera.

was almost odorless. It was used, if possible, immediately after distillation and was kept in a pyrex container coated with black paint on the outside to avoid photochemical action of light. This liquid carbon disulfide was kept in a long pyrex tube, and, to seal it to the camera system, the carbon disulfide was frozen so as to avoid any possibility of explosion. The carbon disulfide container was connected with the camera system by a greaseless metal valve as described by Bodenstein.[6] All the connections up to the camera are greaseless, and copper to glass seals are used wherever metal is connected to the glass system. Any flexible connections to the camera are made with sylphon tubing so as to avoid the use of rubber hose, which may be attacked by the gas.

The acetylene and ethylene used were purified in the manner described by Smyth[7] when used by this author for the determination of the dipole moment.

All the gases are first admitted to a container filled with purest and redistilled potassium to eliminate traces of water and carbon dioxide and

---

[4] K. Lark-Horovitz and E. P. Miller, 1932. Phys. Rev. **42**:915. E. P. Miller, 1933. Rev. Sci. Insts. **4**:379.

[5] Obach, Journal Prakt. Chem. **26**:281-287.

[6] Bodenstein, 1924. Z. f. Phys. Chem. **110**:399.

[7] Smyth, 1925. Journal Am. Chem. **47**:2501.

are then led to a small vessel, which can be cooled with liquid air if necessary. The first portions of the gas are passed through the camera without condensing them so as to remove any volatile impurities taken up by the gas stream in passing through the system. Liquid air is then applied to the Dewar flask of the camera, and condensation takes place on the crystal holder.

TABLE I

Carbon Disulfide Patterns

Film No. 348. CS_2 (purified) deposited on A1—Cu K-alpha. Focusing camera. Computations based on standard lines of A1 at —185°C. (a = 4.025)

Int.	No.	Sin Θ	Spacing
v st	1	.3823	002 A1
m	2	.4321	1.781
m	3	.4523	1.698
m	4	.4756	1.618
m	5	.4960	1.551
m	6	.5105	1.507
st	7	.5407	022 A1
f	8	.5712	1.347
m	9	.5764	1.335
v f	10	.5906	1.303
v f	11	.5990	1.285
v f	12	.6111	1.259
v st	13	.6340	113 A1
m	14	.6578	1.170
m	15	.6622	222 A1
f	16	.6711	1.147
v f	17	.7059	1.090
m	18	.7294	1.055
f	19	.7509	1.025
st	20	.7647	004 A1
f	21	.7965	.966
f	22	.8095	.951
v st	23	.8333	133 A1
st	24	.8361	.920
v st	25	.8549	024 A1
st	26	.8576	.897
v f	27	.8984	.857
v f	28	.9313	.826
v f	29	.9325	.825
v st	30	.9365	224 A1

Film No. 436. CS_2 (purified) deposited on Ag—Cu K-alpha. Debye-Scherrer camera Computation based on standard lines of silver at —185°C.

Int.	No.	Sin Θ	Spacing
st	1	.2091	3.682
v st	2	.2504	3.073
v st	3	.2555	3.012
m	4	.2868	2.683
m	5	.2988	2.575
st	6	std 111 Ag	
st	7	std 002 Ag	
f	9	.4070	1.891
f	10	.4176	1.842
f	8	.3891	1.965
st	11	.4329	1.778
f	12	.4418	1.742
m	13	.4540	1.695
f	14	.4759	1.617
f	15	.4972	1.548
m	16	.5058	1.521
f	17	.5115	1.504
st	18	std 022 Ag	
f (d)	19	.5676	1.356
f (d)	20	.5901	1.304
f	21	.6097	1.262
v st	22	std 113 Ag	
f	23	.6410	1.201
v st	24	std 222 Ag	
v f	25	.6702	1.148
v f	26	.6831	1.126
v f	27	.7030	1.095
v f	28	.7250	1.061
v f	29	.7433	1.035
st	30	std 004 Ag	
v f	31	.7898	.974
v f	32	.8047	.956
v st	33	std 313 Ag	
v st	34	std 024 Ag	
v f	35	.8584	.897
v f	36	.8838	.871
v st	37	std 224	

TABLE I—Continued

Carbon Disulfide Patterns

Film No. 350. CS_2 (purified) deposited on A1—Fe K-alpha (Mn f—al f). Computations are based on standard lines of A1. Focusing camera.

Int.	No.	Sin Θ	Spacing
st	1	.3713	2.602
m	2	std 111 A1.	
m	3	std 002 A1.	
m	4	.5684	1.700
f	5	.5963	1.620
f	6	.6410	1.507
st	7	std 022 A1.	
f	8	.7216	1.339
f	9	.7658	1.261
m	10	.7813	1.236
m	11	.7867	1.228
st	12	std 113 A1.	
m	13	std 222 A1.	
f	14	.8399	1.150
f	15	.8829	1.094
f	16	.8864	1.090
f	17	.9396	1.028
f	18	.9409	1.027
f	19	.9491	1.018
f	20	std 004 A1.	
f	21	.9614	1.005

Film No. 361. CS_2 (purified) deposited on A 1. Cr K-alpha (Va f—A1 f) Line No. 4, (111) of A1 used as base of computations, with film constant from No. 350 = 3.3274° per cm. Focusing camera.

Int.	No.	Sin Θ	Spacing
st	1	.3690	3.099
st	2	.4229	2.704
m	3	.4396	2.601
f	4	.4920	std 111 A1.
f	5	.6382	1.792
f	6	.6677	1.713
f	7	.7027	1.627
f	8	.7563	1.512
f	9	.9037	1.265
f	10	.9176	1.246

Results

The results, as given in Tables 1, 2, and 3, contain measurements with both methods and with different radiations.

While this work was being carried out, information regarding the same substances was obtained in the Crycgenic laboratory in Leyden, Holland. The results by Keesom and de Smedt[8] on carbon disulfide have been interpreted by these authors as evidence for a tetragonal structure. We have found, however, due to the better resolving power of our quipment, that some of the lines reported by these authors have not been correctly interpreted and also, that some lines which they have found do not appear at all if purest carbon disulfide is used. They appear only if the gas can react with stopcock grease and is therefore contaminated. We have not been able to interpret the pattern by assuming a cubic, tetragonal, or hexagonal structure and therefore must assume a structure of a lower symmetry.

In the case of acetylene and ethylene our results agree with the main

---

[8] Smedt,——. Physica 10:1931.

TABLE II

Acetylene Patterns

Film No. 418. C_2H_2 (purified) deposited on Ag—Cu K-alpha (ni-f). Computations based on standard lines of Ag. at —185°C. Debye-Scherrer camera.

Int.	No.	Sin Θ	Spacing
m	1	.2047	3.759
m	2	.2134	3.606
v st	3	.2251	3.419
m	4	.2755	2.793
f	5	.2994	2.570
f	6	.3110	2.474
v st	7	std 111 Ag.	
f	8	.3451	2.230
v st	9	std 002 Ag.	
f	10	.4037	1.906
m	11	.4468	1.722
f	12	.4813	1.599
f	13	.4913	1.566
v st	14	std 022 Ag.	
f	15	.5681	1.355
f	16	.5863	1.313
v st	17	std 113 Ag.	
v st	18	std 222 Ag.	
f	19	.6859	1.122
f	20	.7058	1.090
f	21	.7465	1.031
m	22	std 004 Ag.	
f	23	.7834	.982
f	24	.7932	.970
v st	25	std 133 Ag.	
v st	26	std 024 Ag.	
f	27	.8607	.894
m	28	.9660	.889

Film No. 294. C_2H_2 (purified) deposited on Al—Fe K-alpha (mn-f). Computations based on standard lines of Al. at —185°C. Focusing camera.

Int.	No.	Sin Θ	Spacing
v st	1	std 111 Al.	
st	2	.4640	2.082
st	3	.4712	2.050
v st	4	std 002 Al.	
v st	5	std 022 Al.	
m	6	.7334	1.317
v st	7	std 113 Al.	
v st	8	std 222 Al.	
m	9	.8626	1.120
f	10	.8793	1.099
f	11	.8861	1.090
f	12	.8875	1.089
f	13	.9603	1.006

lines given by Mooey, but again some of the lines which we have found are missing in his pattern. We have not been able to assign a high symmetry structure to these crystals but come to the conclusion that a rhombic or still lower symmetry has to be assumed to explain the complicated diffraction pattern.

For this reason we have been carrying out some experiments with completely monochromatic radiation. In this case it is possible, as has been shown recently, to find distances between the neighbors of any atom by Fourier analysis, and in this way to gain a basis for the interpretation of the quadratic form. These experiments are being continued.

This investigation has been carried out at the suggestion of and under the direction of K. Lark-Horovitz, 1929-1935, whom we wish to

TABLE III

Ethylene Patterns

C_2H_4 (purified) deposited on Cu—Fe K-alpha. Manganese filter. Debye-Scherrer camera. Computations based on standard lines from copper.

Int.	Sin Θ	Spacing
f	.2275	4.396?*
m	.2418	4.136?*
m	.2492	3.882
st	.2647	3.655
m	.2796	3.460
f	.3029	3.194
f	.3291	2.940
f	.3382	2.861
f	.4307	2.246
m	.3820	2.532
st	.4226	2.289
v st	std 111 Cu.	
m	.4783	2.023
m	.4890	1.979
m	.5063	1.911
v st	std 002 Cu.	1.581
f	.6118	1.520
f	.6364	1.463
f	.6614	1.403
f	.6894	
f	.7092	1.364
v st	std 022 Cu.	
m	.8088	1.196
f		

*possibly due to K-beta

thank also for his continuous help and interest. We also wish to thank Mr. A. I. May and the other members of the instrument maker's shop at the Physics Department for the precise workmanship in building the necessary equipment.

CONCERNING THE OPTICAL PRINCIPLES WHICH ARE INVOLVED IN THE HALO PHENOMENON[1]

OLIVER E. GLENN, Lansdowne, Pa.

An observation which was published by John Ruskin in 1851 might have prevented much subsequent error in regard to the phenomenon of the ordinary halo if scientists had continued investigation along the lines suggested. This observation occurs in the first volume of *The Stones of Venice* (Ch. 21, Treatment of Ornament).

> "When the sun rises behind a ridge of pines, and those pines are seen from a distance of a mile or two, against his light, the whole form of the tree, trunk, branches and all, becomes one frostwork of intensely bright silver, which is relieved against the clear sky like a burning fringe, for some distance on either side of the sun."

Ruskin remarks that, among literary men, probably only Shakspeare and Wordsworth had noticed this fact. The allusion by Shakspeare is as follows:

> "But when, from under this terrestrial ball,
> He fires the proud tops of the eastern pines."
> *(Richard II).*

In the panorama mentioned, which contains the pine trees, the observer is seeing two opposite segments of a halo around the sun. This will become theoretically clear if we choose, as a primary type of reflector, a small sphere which has a glossy surface, for example, a marble of china-ware. Place this sphere at a distance of about two feet in front of an unshaded desk lamp L of one (frosted) bulb, the observer being six feet from the lamp. Arrange, also, to move the sphere, at choice, along the line perpendicular to the observer's line of sight toward the lamp. When the sphere is in front of the light no illumination is reflected from the former to the observer. The sphere is then in its completely shaded phase. If moved a considerable distance to one side, the ball shows reflected light only in the form of a faint virtual image of the lamplight. However, when the ball is moved so that it is in the new-moon phase as seen by the observer, the case is very different. Intense illumination in the form of a spot of light P, a so-called brilliant point[2], appears on the sphere as a feature of its crescent illumination. This point maintains its brightness as the sphere is moved back and forth along its line of motion for a short definite distance. W. H. Roever first gave the definitions of brilliant points. His principal definition is as follows:

> A point P is said to be a brilliant point of a surface T with respect to a source of light P_1 and an observer's eye P_2, if the internal bisector of the angle $P_1 PP_2$ is the normal to this surface at the point P.

Thus the observer P_2 sees, in effect, at a brilliant point P, the light itself or a section of it, whereas, when our sphere is moved to one side, what is seen is a virtual image, that is, the light greatly reduced in size and intensity by the curvature of the surface. This is an elementary observation but its significance as a scientific observation has been overlooked more or less. No astronomer, for instance, has ever recognized this as the principle according to which Venus is so brilliantly lighted when she is an evening star. *Primarily* the halo is a result of brilliant point reflection from droplets of water-vapor or of ice, floating in the air between the observer and the sun. This is made clear as follows (FIG. 1):

---

[1] Read in outline before the Academy December 4, 1931.

[2] Roever, 1908. Trans. Amer. Math. Soc. 9:245-279. Roever, 1922. Amer. Math. Monthly 29:149-156.

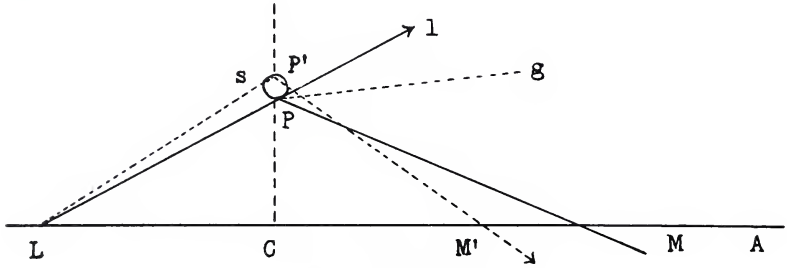


FIG. 1. See text.

Consider a lamp L and an observer M, both fixed in position, and a sphere s on the perpendicular to LM at C. The sphere will represent a droplet in a halo which has C as its center. We have magnified the droplet for clearness. The plane of the halo will be perpendicular to LM. Let l be the ray of light which is tangent to s. Anyone, N, situated a little above l, would see the sphere in its dark-of-the-moon phase. In fact it is necessary for N to come below a line g of somewhat smaller gradient than that of l in order to see the brilliant-point P on s, and P stays visible to N as long as the latter remains within the fixed angle gPh. Below the line Ph, P lapses in brightness, becoming a virtual image reflection. The fixed observer M, being within $<\theta=hPg$, sees the brilliant-point P, one among the myriad which form the halo.[3]

Let us next find the halo's width. As we move s toward C, the vector g turns inward until it eventually intersects LM, as at A. As we continue to move s toward C, A approaches M. The position a', of s when A reaches M, is on the lower boundary of the halo. Next suppose that s is moved along its perpendicular away from C. Then h approaches M, and, if b' is the location of s when h reaches M, b' marks the upper boundary of the halo. The whole area occupied by the halo is obtained by rotating $a'b'$ around LM as an axis. It is well known and is readily verified by use of any glossy sphere for s that, when l is parallel to LM —— the case of a halo of the sun —— the angular radius of the halo is not greater than the 22°. We write $<gPl=t$.

Proposition 1. *To determine the width, W, of the halo and the diameter, 2V, of the dark area within, each as a function of LC, CM,* θ,t, *only.*

Let the small circles in Figure 2 represent droplets of water vapor situated at the extreme upper and lower boundaries, respectively, of the halo. We have $LC=n$, $CM=m$, $CQ=V$. $QP=W$, (Def.), $<gPl=t=<MQK$, $<MPg=\Theta=<hQM$, (Cons.). Let $<CLQ=\beta$, $<QLP=\alpha$, $<CMQ=\delta$, $<QMP=\gamma$.

---

[3] The point h is the intersection with LM, of the line extending from P toward M.

Then, since an exterior angle of a triangle equals the sum of the two opposite interior angles,

$$(\alpha+\beta)=(\theta+t)-(\gamma+\delta),\ \beta=t-\delta,\ \alpha=\theta-\gamma.$$

Also θ, t are fixed angles and $\delta < t$, while by experiment, $\theta+t>\gamma+\delta$, $\delta<22°$. Let $a=\tan(\theta+t)$, $b=\tan t$, then,

$$V=n\tan\beta=n\tan(t-\delta)=(nb-n\tan\delta)/(1+b\tan\delta),$$

$$V=m\tan\delta.$$

Eliminating $\tan\delta$.

$$bV^2/m+(m+n)V/m-nb=O,$$

and the diameter of the dark area is

$$(1)\qquad 2V=-(m+n)/b+\left[(m+n)^2+4b^2mn\right]^{1/2}/b$$

In like manner,

$$V+W=n\tan(\alpha+\beta)=n\tan(\theta+t-\gamma-\delta)$$

$$=\left[na-n\tan(\gamma+\delta)\right]/\left[1+a\tan(\gamma+\delta)\right],$$

$$V+W=m\tan(\gamma+\delta),$$

Eliminating $\tan(\gamma+\delta)$,

$$a(V+W)^2/m+(m+n)\ (V+W)/m-na=O,$$

$$V+W=-(m+n)/2a+\left[(m+n)^2+4a^2mn\right]^{1/2}/2a.$$

Hence the formula for the width of the halo is,

$$(2)\qquad W=\left[-(m+n)/2a+\left\{(m+n)^2+4a^2mn\right\}^{1/2}/2a\right]$$
$$-\left[-(m+n)/2b+\left\{(m+n)^2+4b^2mn\right\}^{1/2}/2b\right].$$

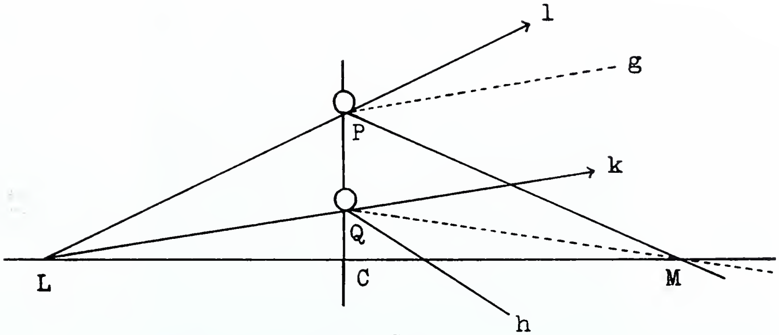


FIG. 2. See text.

Proposition 2. *To determine the diameter, 2V′, and the width, W′, after the light, L, has been removed to an infinite distance* ($n\to\infty$). In this case the rays which come up to the rear of the canopy are parallel ($\alpha\to B\to O$. This is the problem of the halo around the sun or moon. We have only to find the limit of W and 2V above, as $n\to\infty$.

The radicals in (2) may be expanded into absolutely convergent binomial series. The first terms of these series cancel the respective first terms within the brackets and all terms of each series, after the second, approach zero as $n \to \infty$. The second terms of the series combine into,

$$C = (a-b)mn/(m+n).$$

Hence,

$$(3) \qquad W' = \lim_{n \to \infty} C = (a-b)m.$$

Likewise,

$$(4) \qquad 2V' = \lim_{n \to \infty} O = \lim_{n \to \infty} 2bmn/(m+n) = 2bm.$$

The following table shows the respective values of 2V, W, calculated on the basis of formulas (1), (2), (3), (4), from the indicated assigned values of m, n, θ, t. The unit of length is one inch.

m	n	θ	t	2V	W	Photo.
80	10	27°	10°	3.1	4.8	Fig. 3
73	24	27°	10°	6.3	9.3	Fig. 4
71	42	27°	10°	9.2	13.2	Fig. 5
71	∞	27°	10°	25.0	41.0	....

When $n = \infty$ the angle subtended at the midpoint *M* of the camera film by the radius of the dark region within the halo, is about 10°. To this we must add 12° to obtain the angle which subtends the radius of the circle of maximum illumination.

The halo of 46 degrees. Under Roever's definition, concave reflecting surfaces can also give brilliant points. Let *s* in Figure 1 be a transparent sphere (droplet). A ray from the light will enter the sphere and be relayed by refraction so that it is reflected against a point *P′* in the concave side of the spherical surface. It emerges from the sphere and reaches the observer *M′*. The formulary (1),—, (4) still holds. When the angles θ, t (cf. (2)), are $\theta = 24°$, $t = 35°$ this point *P′* is found to be a brilliant point to an observer within θ. Thus we obtain another known type of halo. The radius of its circle of maximum light subtends, at *M′*, the angle 46°, $(n = \infty)$.

Description of an experiment. The accompanying Figures 3, 4, and 5 are dark-room photographs (time exposures) of artificial halos, which were obtained as follows: The pictures show reflected light from a plane canopy of glass beads, the source being a lamp *L* (cf. Fig. 1) placed on the side of the canopy opposite that of the camera. The distance from the canopy to the camera plate, (focal distance), is *m*. The canopy, which is 2.3 feet in width, was woven of strings or series of approximately spherical glass beads of diameter less than ⅛ inch. The beads (turquoise blue) were strung at intervals of ⅕ inch on black, threestrand cotton yarn, to form the series. The series were woven in various designs to form the canopy, but mostly with one series going around in spiral fashion at intervals of ½ inch, other series being strung as diameters all the way across the canopy.

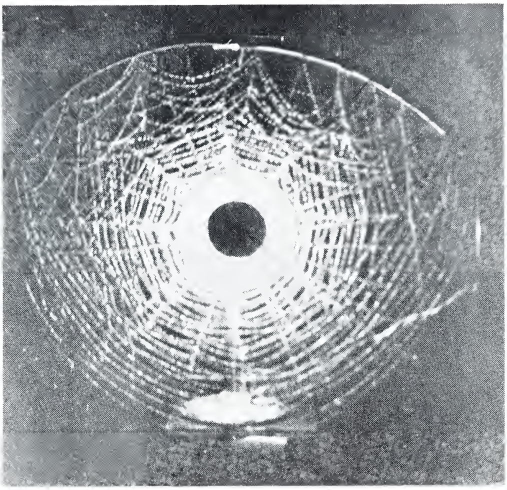


FIG. 3. See text.

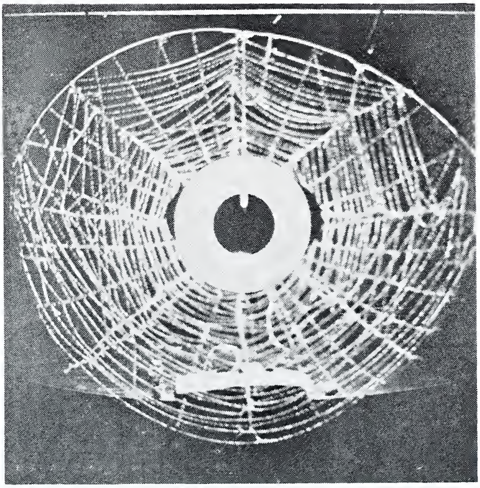


FIG. 4. See text.

One purpose of the construction was to show photographically the individual brilliant points which combine into a halo. On account of the screen at the center, only light which is reflected toward the camera from the beads is intense enough to affect the camera film. Some regret must be expressed for the use of the yarn, since its fuzz caused enough diffraction near the center[4] of the canopy almost to obliterate, in the photographs, the dark interior of the halo. The use of copper wire of a caliber equal to that of the aperture in the beads would eliminate diffraction. It is obvious from the theory, however, that there is a dark circle at the center of the canopy since the beads there are in the dark-of-the-moon phase. Aside from this defect each picture clearly shows a halo. The author considers the photographs as being successful in view of the fact that, in this case, the reflecting wall is only one bead (droplet) in thickness.

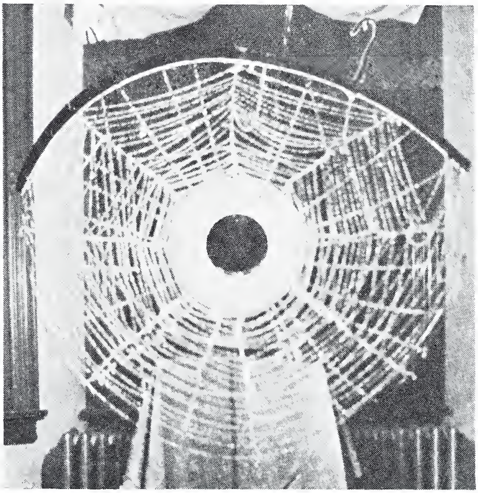


FIG. 5. See text.

The camera distance was about 75 inches, and corresponding to three distances, n, of the light from the canopy, actual measurements of the configurations of the halos on the canopy verified the corresponding calculations, which are summarized in the accompanying table.

The diametral series of beads are regularly eclipsed, that is, pass into the dim virtual image reflection, at the outer edge of the halo in Figures 3 and 4. Note that the halo has a bright part and that, in all cases, there is a gradual decline of its intensity in its outer portions. The bright part corresponds to the angle, (within Θ), of maximum illumination of the brilliant point on a bead. The dark circle is comparatively small when n is small, but, when the incident rays are parallel, the diameter of this interior circle subtends, at the camera plate M an angle of about 20°. Then the dark circle is recognizable as that to be seen in an ordinary halo. It is useful to consider the figure on the canopy as if projected from M upon a distant wall. What the canopy presents to the eye is brilliant rather than obscure.

---

[4] These regions of maximum diffraction have been removed from the pictures. Problem in technique: Find the circle of maximum illumination in Figure 5.

Discussion.—In any landscape where there are trees with glossy leaves, or wet leaves lighted by the morning or afternoon sun, brilliant-point illumination of portions of this foliage will be conspicuous. Such a tree, when nearly between the observer and the sun, shows a bright and charming illumination, and the general appearance of such a landscape would be very different if the optical principles were different from those which we have described. This fact is of importance to landscape painters. When a tree is pictured, against the light of an afternoon sky, as something entirely dark against a bright back-ground, it impresses us subconsciously at once as something unreal. We are accustomed to a fringe of brilliant-point on such a tree. This remark is a severe criticism of a good many paintings. Corot, among others, was a master with brilliant-point light.

Contrary to what is asserted in the present article, in quite all of the previously existing theory concerning halos it is assumed, and, as far as the present writer has been able to find, without adequate demonstration, that refraction of light through ice crystals is the *primary* cause.

PROGRAM OF THE SECTION ON PSYCHOLOGY

Chairman: H. H. REMMERS, Purdue University

1. *The psychology of Charles Darwin. Sister Mary Frederick, C. S. C., St. Mary's College, Notre Dame.
2. *A proposed program of research in attitudes. H. H. Remmers, Purdue University.
3. Further conditions of transfer of training. R. W. Bruce, Wabash College.
4. *Psychology and its twofold relation. Sister Mary Verda, C. S. C., St. Mary's College, Notre Dame.
5. The learning performance of white rats in temporal maze patterns. Maurice R. Graney and Otis C. Trimble, Purdue University.
6. The "recognition spans" of "good" and "poor" readers: A comparative study. Otis C. Trimble and Dorothy H. Asperger, Purdue University.
7. Maze learning in water snakes. Wardell B. Pomeroy and W. N. Kellogg, Indiana University.
8. Relation between the multiple correlation technique and Thurstone multiple factor theory. Merrill F. Roff, Indiana University.

---

*Papers published in this volume.

THE PSYCHOLOGY OF CHARLES DARWIN

Sister Mary Frederick, C. S. C., St. Mary's College, Notre Dame

Charles Darwin was a punctilious and fastidious man. He was supersensitive about doing the urbane thing. This afternoon if he were present with us he would probably feel that we had committed him to an unfortunate social blunder by introducing him, not in the biology section, but in that of psychologists. Yet it was impossible for him, as it is for any of us, to tell what three score years and ten will do with our names. And I still insist on bringing Charles Darwin, Naturalist, with me to this section, for I believe that he it was who, to a great extent, caused psychology to be what it is today—a branch of science.

It is true that Aristotle, with whom psychology may be said to have begun, did not distinguish it from biology, both sciences being considered a part of physics or the study of nature. He even antedated Darwin two thousand years in conceiving a "systematic distinction of levels or states of mental processes, so ordered that each stage presupposes the existence of the lower but not conversely"[1]—the first sugsuggestion of genetic method in psychology. Yet the *περί ψμχηs* of Aristotle contributed more than the work of any single man to construct the *philosophy* of the soul. Psychology for him was the science of the *ψμχη*, the principle of life, and it is from this source that the very term *psychology* derives. He would probably be quite confused, though no doubt sincerely interested, were he to hear discussed today under the heading of psychology, such topics as *The Learning Performance of White Rats in Temporal Maze Patterns* and *The 'Recognition Spans' of 'Good' and 'Poor' Readers.*

The Schoolmen of the Middle Ages, first after Aristotle to make any effort to give a systematic treatment of psychology, were philosophers. With the introduction of Christianity certain psychological problems such as the immortality and progress of the human soul, free will, and moral habits raised the *περί ψμχηs* to one of the most important branches of philosophy.

The outstanding mediaeval problem of universals with its attendant schools, nominalism and realism, also directed much consideration to the origin of ideas. The treatment was yet, however, mostly epistemological, deductive, and metaphysical, and not at all scientific in the sense of empirical or inductive. In the works of Albertus Magnus and Thomas Aquinas, who, more than any other thinkers of the period, popularized Aristotle's psychology, biology, general metaphysics, and theology are constantly interwoven with psychology, as, indeed, they were for many centuries after.

Descrates in the seventeenth century, who with Hobbes and Spinoza, represents the earliest period in modern psychology, was indeed a scientist, but he was also a philosopher.

John Locke's *Essay on Human Understanding* did very much to initiate the method of analytic introspection, one of the outstanding features of modern psychological method. Yet his main interest was not psychological; his contributions to this science were incidental, almost accidental.

---

[1] Stout, G. F., 1928. Dictionary of philosophy and psychology. New York.

Berkeley, Hartley, and Hume, and later the two Mills, pushed on the latent possibilities in Locke's ideas, but they were all deductive in their methods rather than empirical.

Though an eighteenth century German contributed the term *psychology*, and a compatriot of his, Johann Herbart, made contributions to the psychology of interest and inhibition, not even they can be considered responsible for the scientific tendency in psychology today.

In 1859 Darwin published his epoch-making *Origin of Species*, a ponderous and powerful example of inductive, empiric method. Therein he not only canvassed vast territories of plant and animal life, but also touched frequently upon matters intimately connected with human psychology, as, for example, the matter of instincts. Whether those be right who feel with Huxley that Darwin "gave a smashing blow to orthodoxy" or they be more correct who say he gave it its greatest scientific support, certain it is that this master in one work popularized the empirical method. He pushed into the background of the commonplace, thereby, the familiar and not at all startling approach known as the metaphysical.

Even more in the *Descent of Man* (1871), he contributed to the empirical and inductive emphasis in psychology by "raising the whole question of the development of mental powers in men and in animals, with further extension to the more startling probability that moral qualities might have a natural history."[2]

But it was in his *Expression of Emotions* published in 1890 that he gave his fullest expression to his psychological ideas in three laws, which were supposed to account for the origin of all human expressions.

Of what importance in the field of psychology, one might ask, have these contributions of Charles Darwin been? It seems certain that, in his own mind, as we said at the beginning, he considered his life work biology, and psychology only a hobby. In his biography we may read: "He wrote to Dr. Asa Gray, April 15, 1867: 'I have been lately getting up and looking over my old notes on Expression, and fear that I shall not make so much of my hobby-horse as I thought I could; nevertheless, it seems to me a curious subject which has been strangely neglected!' . . .[3]

"Again he says in a letter to Wallace in 1867: 'I have been very glad to see your impression from memory on the expression of Malays. I fully agree with you that the subject is in no way an important one; it is simply a "Hobby-horse" with me, about twenty-seven years old; and *after* thinking that I would write an essay on man, it flashed on me that I could work in some *supplemental remarks on expression*. After the horrid, tedious, dull work of my present huge, and I fear unreadable, book . . . I thought I would amuse myself with my hobby-horse. The subject is, I think, more curious and more amenable to scientific treatment than you seem willing to allow.' "[4]

Even in Darwin's own life-time, this work was considered unfortunate. His friends felt that he would have done better to have ridden his hobby only in private and not to have exhibited his feats thereon in public. His own ever-sensitive nature was quick to feel, too, that he was not at his best nor a success in the work, as is shown in an abstract from his *Life and Letters:*

---

[2] Encyclopedia Britannica (14th. ed.) 18:706-715; 719. 1929.

[3] Darwin, Francis, 1896. Life and letters of Charles Darwin. 2:313-314.

[4] Ibid., pp. 277-278, Appleton. New York.

"I have finished my little book on *Expression*, and when it is published in November I will, of course, send you a copy, in case you would like to read it for amusement. I have resumed some old botanical work, and perhaps I shall never again attempt to discuss theoretical views.

"I am growing old and weak, and no man can tell when his intelectual powers begin to fail."[5]

The criticisms of the work were, as a whole, unfavorable, and even today few think of Charles Darwin's actual offerings in the field of psychology as of any great value.

Yet it is true, we believe, that Charles Darwin, to a great extent, has made psychology what many consider it today, a biological science. Most of its present-day trends may be traced to his door.

Primarily of course he is responsible—and not Aristotle who first really used it—for the effective operation of the genetic method so commonly in use today. To him, too, we attribute the fact that for perhaps most psychologists now the biological is the approach oftenest employed, that animal and human psychology are treated together, that child psychology is classified as a genetic science, and that a school has arisen which accounts for the more difficult problems of the nature of intelligence solely in terms of biological response under varying stimuli.

That more exact, prolonged, and careful use of the empirical method in the study of mind which is so prominent a factor of twentieth century psychological study can, without doubt, be attributed to him. It is probably his greatest gift to the science. On the other hand, we must lay upon him, too, the regrets of the minority that to so great an extent the deductive or philosophical method has been utterly abandoned by psychologists, for too little abstract reasoning in any field would seem to be as deleterious as too much.

Perhaps it would be best to conclude without further comment, but to an old hand in the teaching field it is habitual to provoke discussion, and habits are hard to break. Hence we cannot resist asking whether or not psychology is, on the whole, better off or not for Darwin's having influenced it.

Probably the philosopher H. A. Overstreet has well expressed the opinion of the majority in the following words:

"The science of psychology, as we have indicated, has only just been born. There is every reason to believe that it will yet grow up. As it learns caution and precision, it may even, some day, become a highly respected member of the great council of other sciences."[6]

On the other hand Grace Adams has an article in the *Atlantic Monthly* for 1934 which is both very entertaining and quite expressive of the opposite, but probably minority view. After satirizing the overuse of the I. Q., psycho-analysis, and behaviorism, she concludes:

---

[5] Ibid., p. 349.

[6] Overstreet. H. A.. 1927. A quarter-century of psychology. Century. 113:526.

"Even Joseph Jastrow, who during his forty years' work with the everchanging subject has tempered his enthusiasm with sagacity, has now admitted that 'psychology may not be a science.' "[7]

Which view is better in the light of eternal truth we do not venture to say. In a spirit that may be considered either cowardly or broad-minded or modern, we had perhaps best conclude in the words of Professor Titchener: "Controversies on such questions are natural in a young science, and more especially in a science whose subject-matter touches general human interests so closely. Their resolution must be left to time."[8]

---

[7] Adams, Grace, 1934. The rise and fall of psychology. Atlantic Monthly. **158**:82.

[8] Baldwin, James Mark (Edit.), 1928. Dictionary of philosophy and psychology. 2:382-391. Macmillan. New York.

A PROPOSED PROGRAM OF RESEARCH IN THE GENETICS OF ATTITUDES*

H. H. REMMERS, Purdue University

I. Introduction

That attitudes are presumably closely associated with overt behavior is attested by both scriptural and profane writings. "As a man thinketh in his heart, so is he" finds its modern counterpart in current educational philosophy as exemplified in statements of educational objectives. Such expressed aims as "worthy home membership," "worthy use of leisure," "citizenship," and the omnibus concept of "character" require no detailed analysis or argument to show them as heavily loaded with what may conveniently be called attitudes. The assumption of the psychological validity of this proposition is clearly evident at the present time in the educational procedures in Italy, Germany, and Russia, where public education as a propaganda arm of government is explicit. *No* education in any organized modern society, we submit, can afford to neglect attitudes as outcomes of the educational processes with which it concerns itself. Putative democracies as well as dictatorships of whatever sort must recognize and deal with the problems if they expect to control individual and social behavior to the end of their own survival. Whatever our social and educational philosophy, attitudes as objectives cannot be ignored.

While much has been said and written concerning the importance of attitudes, little has been done in the way of measuring them. We know practically nothing, in any scientific way, concerning the factors that produce one kind of attitude as against another, to say nothing of the optimum conditions for the development of a given attitude. Since specified attitudes are among the important aims of education, it follows that to know whether and to what extent a specified attitude has been achieved, it must be measured.

The work on generalized attitude scales[1] has demonstrated the feasibility of validly measuring a large number of attitudes with a single scale. The chief objection to Thurstone's method of constructing attitude scales has thus been overcome—that of the enormous labor involved in constructing the scales required for measuring even a small number of socially significant attitudes. Investigation of the factors which make and unmake attitudes can thus be carried out at enormously less cost than would otherwise be the case. *A relatively small number of scales will serve to measure substantially all of the attitudes with which any society is concerned as outcomes of education.* To measure any one attitude with a reliability approximately that of educational achievement tests requires about three minutes.

II. Postulates Underlying the Program

Any experimental research involves postulates. It will be best to

---

*This investigation has been aided by a grant from the Josiah Macy, Jr., Foundation.

[1] Remmers, H. H. and Silance, Ella B., 1934. Generalized attitude scales. J. Soc. Psychol. 5:298-312.

Remmers, H. H. and others, 1934. Studies in attitudes—A contribution to social-psychological measurement. Bulletin Purdue University, Studies in Higher Education. 15.

state explicitly the assumptions underlying the program of research here proposed. It is postulated that:

1. Attitudes as entities are insufficiently defined at present for satisfactory measurement of them. For example a "scientific attitude" detached from any object *toward* which the attitude is expressed or expressible may be merely an imaginary quality with no phenomenal existence. Operational definitions of attitudes are necessary, and generalized attitude scales meet this requirement.
2. Attitudes are the dynamics of human action, and as such they have high importance in all individual or group action that concerns society.
3. Educational procedures, curricular content, and experience in general can and do change attitudes.
4. To know whether attitudes as educational objectives are being achieved, they must be measured.
5. The extent to which various factors influence attitudes can be measured experimentally by means of generalized attitude scales. The significant work of Thurstone and Peterson on the influence of moving pictures on high school pupils' attitudes make this perhaps more than an assumption.

III. Type Investigations.

The experimental investigation of factors affecting attitudes will follow a relatively simple pattern of group experimentation. These experiments may use the single group procedure without a control group, or such a control group may be used.

To illustrate: Suppose it were desired to measure the shift in attitudes toward specified vocations by means of a course in vocations such as is frequently given in the high schools. A measurement with one form of the Scale to Measure Attitude toward Any Vocation at the beginning of the course will be compared with a measurement with the second form of the same scale. As a double precaution, a control group of pupils possibly in another school who do *not* take the course may also be measured,[2] since it is always possible that the shifting social continuum apart from the educational procedure involved in the "vocations" course might also produce significant changes in attitudes.

A few type experiments now feasible in terms of generalized attitude scales already constructed may serve the purpose of illustration.

1. An experiment to determine the possibility of shifting attitude toward some racial group such as the negro. Grice[3] found the average attitude of rural Indiana high school pupils extremely unfavorable toward the negro, although in all probability these pupils had seen very few negroes, and were not acquainted with them in face-to-face social relations, since no negroes lived in these rural communities. The effect of information about the social, cultural and economic growth of the negroes, the effect of the reading of imaginative literary productions such as Uncle Tom's Cabin, and, in general, the effect of any educational materials whatsoever related to this topic can be measured. To the

---

[2] It should be noted that Thurstone's conclusion *re* movies in the Payne Fund studies were based upon the single group technique, and that no control groups were used.

[3] See Remmers and Others, *op. cit.*

extent that significant shifts in attitudes occurred, such experiments would imply the need for the validation of curricular content and educational procedures in terms of attitude objectives.

2. The extent to which attitude toward a proposed curricular change can be shifted by means of an editorial campaign in a newspaper can be made the subject of experimenattion. To make the illustration concrete, let us suppose that it is proposed to introduce a course in philosophy at Purdue University, where such a course is not now offered. Prior to the editorial campaign in the student paper an adequate sampling of student attitude can be obtained by means of one form of the Scale to Measure Attitude toward Any School Subject.[4] Following the editorial campaign designed to show the desirability of a course in philosophy (and, if desired, at intervals during the campaign) further measurement will reveal the efficacy of the campaign. This general type of experiment obviously has many possible variants and applications.

3. Suppose that attitude toward the New Deal is a variable of educational concern in a course in current problems. The effect of any definable curricular content, arguments pro and con, class discussion, etc., bearing on the problem can readily be evaluated by means of the Scale to Measure Attitude toward Any Social Institution.[5]

4. Again, suppose that an industrial problem of current concern be at issue, such, let us say, as labor representation through the company union versus the American Federation of Labor. Suppose this problem to be taken up in a course in industrial personnel or industrial management. A presentation of relevant materials, study of such materials, class discussions, etc., can be measured for their individual or combined effects on attitude toward one or the other method of representation.

5. Suppose again that the effect of a radio program designed to shift attitudes were to be evaluated. Obviously scales of the sort here under construction would make such investigation a relatively simple matter. This holds for the influence of moving pictures, advertising, speaking campaigns, etc.

6. In general the foregoing illustrations will make clear the possibility of evaluating the achievement of attitudes viewed as educational objectives and outcomes. That attitudes so viewed are of first-rate social and educational importance probably needs no extended argument.

7. Apart from the experimental investigation of factors affecting attitudes there are surveys of existing attitudes which should prove fruitful. For example, relatively brief surveys of attitudes of high school and college students toward various school subjects have already revealed significant variations in attitudes toward these subjects. If, as seems reasonable, it be assumed that student attitudes toward curricular offerings are of importance in relation to achievement in these subjects, such surveys should be extended until sufficiently representative data are obtained to give a picture of the total situation within a given school, school system, state, nation, or other geographical, educational, or

---

[4] See Remmers and Silance and Remmers and others, *op. cit.*

[5] See Kelley, Ida B. "The construction and validation of a scale to measure attitude toward any social institution" in the Monograph by Remmers and Others, *op. cit.*

governmental units, to the end that educational practice may be more intelligently guided by such findings.

IV. Scope of the Proposed Program

In accordance with postulate 1 page 242, it is proposed to assemble a list of the more important objects of attitudes with which education should be concerned by a survey particularly of the literature dealing with education, sociology, economics, and the social sciences in general. To supplement this list, a questionnaire addressed to a representative sampling of educators, social philosophers, sociologists, business men, and others presumed to have competence in the matter will be sent out and the returns analyzed. The obtained list of attitudes will then be related to generalized attitude scales already constructed to determine to what extent additional scales may be required.

At the same time, some experiments of the type previously outlined can be initiated and carried through. These will serve as further orientation in the procedures which seem most promising in further prosecution of the general program. An experiment on shifting attitude toward a racial group by means of allowing the experimental subjects to read a short story dealing with a racial situation (Jews in Germany) is now under way and should be extended. Preliminary results are positive. The experiment on the effect of an editorial campaign on attitude toward a course in philosophy has been completed. In general the areas of most needed experimentation will be determined from the survey described above.

The proposed researches will have theoretical implications with respect to learning incentives and certain areas of social psychology. The practical implications concern educational procedures—their validation and possible redirection.

PSYCHOLOGY AND ITS TWOFOLD RELATION

Sister Mary Verda, C. S. C., St. Mary's College, Notre Dame

The establishment of a psychology section in The Indiana Academy of Science, and the extension of membership by this learned group to the teachers of this subject, gave rise in my mind to the old, but ever-recurring question: Is psychology a purely positivist science, or is it a philosophical science, or is it related to both?

To formulate a correct answer to a question so far-reaching in import makes it necessary to determine precisely the scope of psychology. At present there is no definition of the term that meets with the approval of all students of the science. Even a cursory study of ancient and modern texts on the subject reveals a striking lack of unity in the concept of this discipline.

The name psychology is by no means as old as the science itself. Consequently, the term does not define for us the science. Philip Melanchthon of Germany introduced the term at the end of the sixteenth century, and it was popularized in the eighteenth by Christian Wolff. Translating the Greek roots (*psychē, logos*) literally, psychology would mean the science of the soul. However, a careful study of the history of psychological thought proves that such is not the original concept of psychology.

In the fourth century B. C., the first scholar of antiquity, Aristotle, scientist and philosopher, regarded psychology as a part of physics, the science of all corporeal beings in as far as they are subject to change, which depends on First Philosophy or Metaphysics, the science of the principles of all being. The subject matter of psychology was man, composed of body and soul, and its method, internal and external observation and reasoning. In his treatises *De Anima* and *Parva Naturalia*, Aristotle made a remarkable attempt to analyze the nature of the soul, its powers, and mental phenomena. He says:

> "Our aim is to grasp and understand, first its (soul's) essential nature, and secondly its properties; of these some are thought to be affections proper to the soul itself, while others are considered to attach to the animal (i.e. the complex of soul and body) owing to the presence within it of the soul . . . . which ought we to investigate first, the whole soul, or its parts? . . . . Again which ought we to investigate first, these parts or their functions, mind or thinking, the faculty or the act of sensation, and so on?"[1]

Coming to the Middle Ages, we find the incomparable scholar and eminent Christian philosopher, Thomas Aquinas, in perfect accord with the pagan Aristotle. With him, likewise, psychology is a most important chapter of physics, because man is the microcosm and the central pivot of all nature. The matter treated by Aquinas in questions 75 to 90 of pars prima of the *Summa Theologica* could easily be detached and edited as a treatise on psychology. The problems are divided into two groups, the one relative to the nature of man, the other to his mental activities. It is clear from the great scholastic's writings that the proper scope of psychology is man composed of body and soul; and not soul alone, or mental phenomena alone.

---

[1] *De Anima*, p. 402, Eng. Trans. Oxford. 1931.

The *Summa* plainly states:

> "We shall treat first of the nature of man, secondly of his origin . . . . the first object of our consideration will be the soul . . . . we shall first treat of what belongs to the essence of the soul; secondly, of what belongs to its power; thirdly, of what belongs to its operation."[2]

This conception of the scope of psychology, which linked it both with science and philosophy, was, generally speaking, held until the seventeenth century,—a century rich in scientific achievement which marks a conflict between scientists and philosophers that unfortunately persists until the present day. The marvelous discoveries of Copernicus, Galileo, Kepler, Newton, Torricelli, and Lavoisier, effected a complete revolution in the sciences of astronomy, physics, chemistry, and biology. In consequence, a number of hypotheses long associated extrinsically with Aristotelian or scholastic philosophy had to be discarded. Failing to perceive that the abandonment of such scientific theories would in no wise affect the great organic and constitutional doctrines of their philosophy, a group of short-sighted Aristotelian philosophers made themselves ridiculous by seeking to defend the exploded physical hypotheses. Reasonably enough, a philosophy which tolerated such proved absurdities was soon discredited; and scientists felt urgently impelled to cut away from the past and to begin anew the quest for knowledge. And so, from this period—the dawn of the sciences of observation and experiment, may be dated the unfortunate divorce between science and philosophy, a divorce keenly perceptible even today in the psychological discipline.

From now on, a common feature of all definitions of psychology is the limitation of its scope to the phenomena of the mind. The true founder of empirical psychology, psychology as a science of mental phenomena, is John Locke (1632-1704). He clearly distinguishes psychology from physics and metaphysics. In the Introduction to his essay, "On Human Understanding," Locke says:

> "I shall not at present meddle with the physical consideration of the mind, or trouble myself to examine wherein its essence consists, or by what motions of our spirits, or alterations of our bodies, we come to have any sensation by our organs, or any ideas in our understandings, and whether those ideas do in their formation, any or all, depend on matter or not. . . . It shall suffice to my present purpose, to consider the discerning faculties of a man as they are employed about the objects which they have to do with."[3]

With Locke a tradition began which with minor modifications was continued without interruption by Hume, Hartly, and Reid of the Scottish School; by the two Mills, Bain, and Herbert Spencer, British adherents of the Associationist School; by Royer-Collard and Jouffroy of the French School; and by the psycho-physicists, Fechner and Wundt, of the German School. As the name indicates, psychology in the latter school developed into the science of inner or mental facts, and of their relations to their physical and physiological concomitants.

---

[2] *Summa Theologica*, I, q. 75, p. 3, Eng. Trans. London. 1922.

[3] Essay on Human Understanding, Introduction, p. 17. Chicago. 1917.

Locke's conception of the scope of psychology is defined in most of the current American writings. William James, the psychologist of greatest influence during the past thirty odd years, describes psychology as "the Science of Mental Life, both of its phenomena and their conditions."[4] Ladd considers it "the systematic description and explanation of the phenomena of consciousness as such."[5] McDougall defines it as "the positive science of living beings."[6] To Dewey, psychology is "the science of facts or phenomena of self."[7] Woodworth describes it as "the scientific study of the activities of the individual."[8] Pillsbury names it "the science of behavior and the knowing functions of man."[9] Watson limits its scope to the "objective study of human behavior."[10]

From these few typical definitions it is fair to conclude that the majority of non-scholastic psychologists all the way from the seventeenth century down to the present day consider psychology a purely positivist science from which all philosophical problems are to be excluded. But is it practically possible for the psychologist to preserve a philosophically neutral attitude in the explanations of the treatment of the higher intellectual processes? Is a psychology adequate that confines itself to an analysis of mental phenomena alone? Again, is it possible to give a rational explanation of such mental products as universal concepts, the notion of moral obligation, responsibility, personal identity, and the many mental diseases, when the psychologist divorces the phenomena of the mind from its inner nature? Perhaps answers to these questions can be found in the neo-scholastic psychologist's conception of the scope of this subject.

Ordinarily, the neo-scholastics describe psychology as "the philosophical science which investigates the nature, attributes, and activities of the soul or mind."[11] Thomas Verner Moore, a leading member of the group, defines it as "the science of human beings developed by an analysis of their mental life by experiments, by observations, by everything that will enable us to obtain an insight into the minds of men—how they know, how they think, how they reason, how they feel, how they react in the difficulties of life."[12] This scope meets the demands of science and of philosophy, namely, a cataloguing of facts, establishing the relations between them, and ascertaining their relation to cause, both the proximate and the ultimate.

A truly scientific psychology should comprise an experimental investigation of mental activities; that is, mental processes, mental products, and mental dispositions—then from the character of these activities by synthesis, to arrive at the metaphysical conclusion as to the nature of mind. Any adequate study of the mind must naturally present itself in two stages: empirical psychology, the study of the phenomena of the mind by internal and external observation and experiment, and rational or metaphysical psychology, a study of the nature of the subject of these activities or phenomena with its attributes, by both the inductive and the deductive method. The intrinsic connection between many questions of the two stages are so indissoluble that they cannot be considered apart. Although separated for teaching-purposes, they are organically connected.

---

[4] Principles of Psychology, vol. 1., p. 1. New York. 1902.
[5] Outlines of Descriptive Psychology, p. 3. New York. 1900.
[6] Outlines of Psychology, p. 1. New York. 1923.
[7] Psychology, p. 1. New York. 1891.
[8] Psychology, p. 3. New York. 1929.
[9] Essentials of Psychology, p. 2. New York. 1930.
[10] Psychology from the Standpoint of a Behavorist, p. 9. New York. 1929.
[11] Catholic Encyclopedia, vol. 12, p. 457. New York. 1907.
[12] Dynamic Psychology, p. 10. Chicago. 1926.

From the nature of what should be the adequate scope of psychology, the above seems to be the correct answer to the question raised in this paper. In its empirical branches, psychology is related to positivist science, and in its study of the ultimates of the root-principle of mental phenomena, to philosophical science. May we not hope that The Indiana Academy of Science by bringing together the natural scientists and psychologists will effect in the twentieth century what the seventeenth failed to achieve—a rapprochement between philosophy and science.

PROGRAM OF THE SECTION ON ZOOLOGY

Chairman: J. P. Scott, Wabash College

1. *Photoperiodicity in the spawning reaction of Pennaria tiarella. E. G. S. Baker, Wabash College.

2. *Bite of the prairie rattlesnake, Sistrurus catenatus Raf. Marcus W. Lyon, Jr., South Bend.

3. *Insects of Indiana for 1935. Major insect problems. J. J. Davis, Purdue University.

4. *Vultures in Indiana. Amos W. Butler, Indianapolis.

5. Evolution and the embryology of the guinea pig. J. P. Scott, Wabash College.

6. Studies on the insect fauna of the black locust in Indiana. B. E. Montgomery and H. E. Brown, Purdue University.

7. Neurotics and Neurasthenics: Biologically. Robert Hessler, Indianapolis.

8. *Occurrence of unusual Rhopalocera in Indiana. Fred T. Hall, Wabash College.

9. A phoebe nine years old and breeding. S. E. Perkins, III., Indianapolis.

10. Strange bird associates. S. E. Perkins, III., Indianapolis.

11. *Sedimentation in Winona Lake and Tippecanoe Lake from 1930 to 1935. D. H. Miner, Kansas City, Mo., and Will Scott, Indiana University.

12. Diurnal oxygen variations in the West Fork of White River, Indiana. Stacy C. Denham, Indiana University.

13. Physiographic and summer seasonal succession of protozoa in a series of ponds near Hammond, Indiana. Murvel R. Garner, Earlham College.

14. Experiments on the gonad-pituitary-adrenal relationships in the rat. Robert L. Kroc, Indiana University.

15. *The salamanders of Putnam County, Indiana. A. E. Reynolds and E. G. Black, De Pauw University.

16. Independent differentiation of the chick stomach rudiment in chorio-allantoic grafts. Albert E. Reynolds, De Pauw.

17. Artificial insemination of the honey bee. Jay Smith, De Pauw University.

18. Sexual inversion in Mollusca, with special reference to the ship worm, Teredo navalis. B. H. Grave, De Pauw University.

19. *The distribution of the accumulated sediment in glacial Lake Winona. Ira T. Wilson, Heidelberg College.

20. Hemiptera of Indiana. I. Family Gerridae. H. O. Deay and G. E. Gould, Purdue University.

21. *Hemiptera unrecorded from Indiana. H. O. Deay and G. E. Gould, Purdue University.

22. A signal marker for use with physiological and pharmacological apparatus. W. A. Hiestand, Purdue University.

23. *An annotated list of the Bythoscopinae of Indiana (Cicadellidae, Homoptera). D. W. La Hue, Purdue University.

---

*Papers published in this volume.

24. *The habits and early stages of the dragonfly, Gomphaeschna furcillata Say. C. H. Kennedy, Ohio State University.

25. The determination of the isoelectric point of brain tissue. C. A. Behrens and J. F. Barker, Purdue University.

26. Epidemiological research in human helminthology. W. H. Headlee, Purdue University.

27. *Herpetological notes from Northern Indiana. Chapman Grant, San Diego, California.

28. *Herpetological notes from Ft. Knox, Kentucky. Chapman Grant, San Diego, California.

Papers 19 to 24 and 27 and 28 were read by title. Titles 27 and 28 were received too late to be included in the printed program.

PHOTOPERIODICITY IN THE SPAWNING REACTION OF PENNARIA TIARELLA McCr.

E. G. STANLEY BAKER, Wabash College and Marine Biological Laboratory[1]

The phenomenon of photoperiodicity has been the subject of an increasing amount of attention over the last few years. It was first seriously studied by Garner and various others beginning about 1920. He coined the word for use with reference to flower production in relation to light in various plants. He divided plants into three groups: (1) "short-day," which bloom only in a light day of 12 hours or less, (2) "long-day," which bloom only when the light day is longer than 12 hours, and (3) "everblooming," which are able to bloom under a wide range of light conditions. While he found various vegetative responses to light in various plants and plant groups, flowering, the reproductive process in plants, seemed to be almost universally and directly controlled by light.

Since this time various phases of the reproductive process in animal groups, particularly the time of the shedding of the gametes, have been found to have a direct photoperiodic relation. Probably the most work in this line has been done by Bissonnette, who has demonstrated a direct seasonal photoperiodicity in gonadal activity in both starlings and ferrets.

Pennaria tiarella McCr. is a quite typical colonial marine hydroid of the family Tubulariae. It has an alternation of sexual and asexual generations, but the sexual medusae are somewhat reduced in importance in the life cycle. The polyp, or asexual form, is quite typical, growing in colonies attached to Fucus or other sea-weed or attached to pilings about three feet under the water level. Individual stalks, unless the colony is too dense, are rather feather-like in form, being branched alternately and with a single hydranth at the end of each branch.

The medusae, or sexual individuals, grow attached to the hydranth about midway between the upper and lower rows of tentacles. As many as three medusae may develop on one hydranth. The medusa, though somewhat degenerate, is small but typical. It has a small velum but no tentacles. Sexual products mature in the medusa attached to the manubrium and are discharged by the contractions of the velum and bell, complete discharge often taking as much as two hours. Fertilization and development are typical. The medusae may break loose from the hydranth and swim about before they discharge the eggs and sperm, but more frequently, under laboratory conditions at least, they discharge before breaking loose. After discharge the medusae degenerate rapidly.

The season for Pennaria is rather long. This year the first mature eggs were obtained July 2, and they were still plentifully available when the work was discontinued September 12. The sexual products are discharged by the medusae between the hours of 8 and about 11 p. m. This time is practically constant either in nature or under laboratory conditions.

---

[1] My sincere thanks are due Dr. F. R. Lillie of the University of Chicago for making possible my stay in Woods Hole and Dr. L. G. Barth of Columbia University and Dr. B. H. Grave of DePauw University for help and facilities for this work.

The cause of this daily periodicity has never been demonstrated. Water temperature is not a significant factor in view of the fact that there is no appreciable change in spawning time throughout the entire season. Tide is not significant, as tide times change constantly throughout the year, and spawning takes place quite as regularly in a dish of running sea water in the laboratory as in the ocean. Though this daily periodicity would suggest light as a significant factor, G. T. Hargitt (1900) reported that light conditions had no effect on spawning.

Experimental results obtained this summer at the Marine Biological Laboratory definitely indicate, however, that light is a significant factor in controlling the spawning reaction. Pennaria was placed in running sea water in dishes that had been painted with black Duco to exclude all stray light. These were then placed under 75-watt clear lamps which were curtained with black cloth, again to exclude the stray light. The cloth curtain was then tied tightly around the dish. Under these controlled conditions spawning could be produced practically at will at any hour of the day or night simply by varying the light conditions.

It was definitely indicated that light conditions during the growth period of the medusae buds, rather than at the time of spawning, constitute the controlling factor. Relatively ripe medusae from fresh material will spawn at the normal time regardless of whether they are put under the light for an abnormally long time or placed in the dark much earlier than normal. But, if the material is selected so that it contains all or mostly young, immature buds, the spawning time of these can be regulated practically at will by regulating the periods of light and darkness. Likewise the spawning of immature buds is completely inhibited by continuous darkness and almost completely inhibited by continuous light. To get any appreciable percentage of immature medusae to mature and spawn it is necessary to have some sort of a fairly regular alternation of the periods of light and dark.

There is little in the data at hand to indicate anything as to the nature of the mechanism involved in this light reaction. Hasty examination of the data indicates that spawning usually takes place between 20 and 28 hours after the beginning of the last preceding dark period. This may happen even though the animals are under a strong light at the time. A few attempts were made to discover a differential effect as between light of the various wave lengths, but as yet, anyhow, no significant difference has been detected.

Bibliography

Bissonnette, T. H., 1933. Light and sexual cycles in starlings and ferrets. Quart. Rev. Biol. 8:201-208.

Hargitt, G. T., 1900. Natural history and development of Pennaria tiarella McCr. American Naturalist. 34:387-417.

Kellerman, K. F., 1926. A review of the discovery of photoperiodism. Quart. Rev. Biol. 1:87-95.

BITE OF THE PRAIRIE RATTLESNAKE, SISTRURUS CATENATUS RAF.

Marcus W. Lyon, Jr., and Charles Allan Bishop, South Bend

Snakebite anywhere in the United States is a comparatively infrequent accident. As Indiana is well populated and cultivated and located in the north, snakebite in this state is a very infrequent accident; and, owing to the small size of the most common venomous species, a fatality or other serious result is rare. Knowledge of proper treatment of snakebite is singularly lacking, so that it may not be inappropriate to call attention to it as practiced with excellent results in more southern states, especially Texas, where poisonous snakes are more abundant and larger in size.

There are only five species of poisonous snakes in Indiana (Hay 1892): the banded rattlesnake, *Crotalus horridus* (p. 536); the massasauga, or swamp rattlesnake, *Sistrurus catenatus* (p. 534); copperhead, *Agkistrodon contortrix* (p. 531); of very doubtful occurrence, the water moccasin, *Agkistrodon piscivorus* (p. 592); and the very small, rare coral snake, *Elaps fulvius* (p. 529). The last named snake is zoologically related to the Old World cobra more than to the others. It lives mostly underground, seldom bites, and is of negligible importance. The other four snakes constitute a well marked group known as the pit vipers because of the pit in front of the eye, all closely related, and each producing a more or less similar type of venom. They are members of the family Crotalidae. The most common of the four in Indiana is the massasauga, or swamp rattler, which is of common occurrence in the meadows in the northern part of the state.

Two cases of serious poisoning by the massasauga came to our attention in the summer of 1935, one in an adult in St. Joseph County, who was treated by us as a patient, and the other a child in Laporte County, who died, according to authentic newspaper accounts. Our own case is here briefly reported, and Dr. W. W. Ross has kindly furnished observations on the Laporte case.

The chief action of rattlesnake venom is on the blood, the blood vessels, and the circulation. The blood corpuscles become swollen and then undergo hemolysis, the vessel walls are injured, allowing blood to escape into surrounding tissues, and the blood pressure is diminished. There is also general necrosis of the tissues about the point of inoculation. The poison does not have marked neuro-toxic properties, as is the case of the cobra and allied snakes. There is a marked increase in the ratio of the corpuscles to plasma. In normal cases of snakebite the poison is carried centrally and slowly by the lymphatics (Essex and Markowitz, 1930).

As mentioned, the most common venomous snake in Indiana is the massasauga, or swamp rattler, *Sistrurus catenatus*, which is a frequent inhabitant of the meadows in the northern portion of the state. Fortunately, it is a small animal; and its bite, while it may be serious, is seldom fatal. It is not a reptile to seek shelter about buildings, which probably accounts for the fact that children are infrequently bitten. As a rule only adults are attacked. The larger the animal bitten, the less severe the consequences, the poison being toxic approximately according to the body weight of the victim. The severity of the bite depends in large part on the snake's making a successful inoculation of the poison, as well as on the quantity injected, which as a rule varies in proportion to the size of the snake. The poison sac may be much depleted of poison, due to the snake's having just bitten a victim. It requires as much as a week for a venomous serpent to refill the poison sacs after complete emptying. In our own case the snake had evidently previously struck, since a large undigested meadow mouse (*Microtus pennsylvanicus*) was found in the stomach.

Every case of snakebite poisoning should be treated with serum, provided it is available (Crimmins, 1927, 1929, 1934). The figures published by Githens (1935) show the decided lessening in mortality since the use of serum. Probably more important than the use of antivenin, which at best contains only a few neutralizing doses of toxin, is free incision at the site of the bite with well applied suction (Jackson, 1927, 1929). This method has been used very successfully by Texas physicians in cases of bites of large rattlesnakes. The time-honored whisky is more synergistic to the venom than antidotal. Injections of potassium permanganate are practically useless, as the normal tissues rapidly absorb it, and its activity is lost.

Suction should be applied for a total of one hour and a half to two hours in five applications, for 20 hours after the patient has been bitten. If the bite is particularly severe, cuts should be made through the skin of the limb affected, above the bite, and suction should be applied to them.

It has been shown that incision and suction will save dogs after four minimum lethal doses (Jackson and Harrison, 1928) when the treatment has been delayed as long as one hour. The material removed, even after several hours, is still toxic when injected into appropriate animals. As one syringe of antivenin neutralizes but one minimum lethal dose, it is readily seen how effective incision and suction are, and also the necessity for using more than one syringe full of antivenin for serious bites.

There is now on the market available in most of the better drugstores a pocket outfit consisting of a piece of rubber tubing to apply above the bite as a tourniquet, a blade for making the incision, and a strong suction bulb, with complete directions for using. Anyone who expects to encounter the possibility of snakebite ought to carry such an outfit in his pocket. The tourniquet should be applied gently and released for 10 out of every 30 minutes. At best, the venom is only slowly absorbed. Instances are known in which gangrene has been caused by the use of a tourniquet, and the patient would have been better off if none had been applied.

In Githens' (1935) table only a few bites of the massasauga are recorded, with no fatalities. That the bite may be more serious than statistics show is indicated by our patient, as well as by the fact that during the past season a child died in Laporte County from a bite of undoubtedly this species of rattlesnake.

Case Reports

1. Mr. T. J., farmer, Polish, white, 72 years, living in St. Joseph County near the Laporte County line.

Was mowing hay July 2, 1935, about 8:00 a.m. Weeds clogged teeth of the mower. He stopped the machine and, in clearing out the weeds, felt a sting in his left little finger. Looking for the cause of it, he noticed a medium-sized snake which had been partly cut in two by the mower. He went to his home where someone tied a handkerchief tightly about his wrist.

He came to us for medical attention about one hour after the bite. Aside from a complete swelling of the entire hand, which was probably caused by the tightly tied handkerchief, the patient appeared in normal condition, and we were unable to find the fang marks on his little finger, probably owing to the fact that his hands were much calloused and the epidermis roughened in many places.

The ligature was removed and the patient put to bed in spite of the fact that he seemed normal and showed no systemic symptoms. In fact, we were skeptical of the patient's having been bitten by a venomous snake, and insisted that his relatives fetch it to us. On seeing it we promptly identified it as the massasauga, or swamp rattler, *Sistrurus catenatus*. Its length was 18 inches (450 mm.).

About two hours after being bitten, the patient began to show symptoms of poisoning. During the course of the day he vomited several times, felt weak and became dizzy on standing up. He soon experienced pain in the little finger and also in the left arm, and at times broke out into a perspiration. The little finger gradually became reddened and much swollen, while his entire hand also was swollen. Warm compresses of magnesium sulphate in water were applied to the hand during the day. Morphine and amytal were administered for relief of pain, anxiety, and restlessness.

At six o'clock he was transferred to St. Joseph Hospital, South Bend, and remained there for a period of six days.

Antivenin for North American Crotalidae was given to him, after much delay in getting it, about 12 hours after the original bite. This seemed to relieve the pain, but the swelling and discoloration of the finger increased. His arm began to swell and to become edematous. It became much discolored especially along the inner side, with large ecchymotic blotches.

During the first night he was given morphine for the relief of pain, and phenobarbital, 1½ grains. Warm dressings to his hand and arm were continued. During the next two days the patient was given three additional 10 cc. doses of North American Crotalidae antivenin. Warm compresses were still kept placed about the patient's hand and arm. On the third day the end of the little finger looked gangrenous, and was much swollen and livid. Much of his hand was also discolored, and also his arm almost to his shoulder. The axillary glands were tender. At this time his little finger was incised, and much bloody material oozed out.

From that time on, the patient made a rapid and uneventful recovery, except that his finger had to be dressed occasionally. About the tenth day the patient developed a characteristic serum rash.

The leucocyte count 9 hours after the bite was 11,300, polymorphonuclears 84%, and nuclear index depressed to 5. The red count was 4,440,000, hemoglobin 86%. The fragility test was essentially normal, though the cells actually appeared somewhat more stable than the normal control that was done at the same time. The icterus index was only 7.

The following day the white count was 11,100. The urine showed a two plus albumin reaction.

During the first four days in the hospital the patient had a slight fever, up to 100.5, this gradually declining and becoming normal on the fifth day. The pulse rate ranged from 60 to nearly 90 during the febrile period, and once, on the sixth hospital day, reached 105. The respiration rate remained essentially normal throughout.

Blood pressure on admission $\frac{110}{85}$. Six months later $\frac{140}{90}$.

There were not apparent nervous symptoms aside from those caused by the pain and swelling in the finger, hand, and arm. There was some anxiety on his part during the first 24 hours, but subsequently he appeared quite phlegmatic.

2. Contributed by Dr. W. W. Ross, LaPorte, Indiana.

"On August 24, 1935, I was in the Hospital, when a child four years old was brought in because of having been bitten by a rattlesnake; there was a tight bandage about the wrist causing the hand to be cyanotic; the bite was on the back of the middle finger. It had evidently been caused by a rather large snake, as the fang wounds were about three-eighths of an inch apart.

"This was the fifth case of rattlesnake bite which I have cared for in the past ten years. The first two received antivenin in addition to the usual local treatment, and made uneventful recoveries. The next two were only treated locally in the classic way, and made uneventful recoveries. Because of the uneventful recoveries in previous cases and the rather modest claims made regarding the benefits to be obtained from use of antivenin, as well as the fact that there was no antivenin in town, and as its expense is a burden on patient's family unless it is absolutely necessary, I did not use antivenin for nearly 48 hours. The first dose seemed to produce slight benefit, but later ones did not.

"The area beneath and about site of wound was excised (under general anaesthesia), suction was applied, and then wet boric acid dressings. A few hours after excision the wound commenced to ooze blood. This continued until at the end of two days stitches were taken in the side of the fingers to catch up the lateral arteries; but the oozing continued. About the beginning of the fourth day the child began to appear anemic entirely out of proportion to the amount of blood lost. Blood smears appeared to show hemolysis of the blood.

"He died on the seventh day, apparently from anemia, due to hemolysis."

References

Crimmins, M. L., 1927. Facts about Texas snakes and their poison. Texas State Journ. Med. 23:198-203.

Crimmins, M. L., 1929. Poisonous snakes and the antivenin treatment. South. Med. Journ. 22:603-605.

Crimmins, M. L., 1934. Snakebites and saving of human life. Military Surgeon 74:125-132.

Essex, Hiram E. and J. Markowitz, 1930. The physiologic action of rattlesnake venom (crotalin). I. Effect on blood pressure: symptoms and post mortem observations. II. The effect of crotalin on surviving organs. III. The influence of crotalin on blood, in vitro and in vivo. IV. The effects on lower forms of life. V. Some experiments on immunity to crotalin. Amer. Journ. Physiol. 92:317-348. VI. The effect of crotalin on a visceral organism. VII. The similarity of crotalin shock and anaphylactic shock. VIII. A comparison of the physiologic action of crotalin and histimine. vol. cit. pp. 695-706.

Githens, Thomas S., 1935. Snakebite in the United States. Scientific Monthly 41:163-167.

Hay, O. P. 1892. The Batrachians and the Reptiles of Indiana. Ind. Dept. Geol. Nat. Res. 17th Ann. Rep., 1891:412-610.

Jackson, Dudley, 1927. First aid treatment for snakebite. Texas State Journ. Med. 23:203-209.

Jackson, Dudley, 1929. Treatment of snakebite. South. Med. Journ., 22:605-607.

Jackson, Dudley and W. T. Harrison, 1928. Mechanical treatment of experimental rattlesnake venom poisoning. Journ. Amer. Med. Assoc., 90:1928-1929.

INSECTS OF INDIANA FOR 1935[1]

J. J. DAVIS, Purdue University Agricultural Experiment Station

Following a year of extreme drought and high temperature, 1935 was quite the opposite with high rainfall and low temperatures. The fall months of 1934 were provided with an abundance of precipitation, following the dry summer, which was favorable to such insects as Hessian fly but somewhat unfavorable to others, as the chinch bug. The winter was reasonably mild and not severe on overwintering insects normally affected by cold winters. The weather of the season beginning with spring activities of insects was favorable for many insects as the Hessian fly, European corn borer and armyworm, but unfavorable to certain other potential pests including the codling moth and chinch bug. The accompanying table (Table I) gives an idea of the weather of the year, which, if compared with a similar table for 1934 accompanying the insect record published in the last proceedings, shows clearly the contrast of the two years.

Field Crop Insects

At the beginning of the season the chinch bug (*Blissus leucopterus* Say) was the anticipated outstanding insect problem of the year, as it had been the previous season. Throughout the northern two-thirds of the State bugs went into winter quarters in enormous numbers in spite of the unfavorable rainy weather. In the spring of 1935 they were still in very large numbers, ready to fly from their winter quarters to small grain fields. Due to the damp conditions when they entered winter hibernation, a large winter mortality resulted because of the prevalence of the white mold fungous disease. The disease and resulting mortality was especially notable in the tier of counties bordering Illinois, where the bugs hibernated in unbelievable numbers and necessarily under very crowded conditions, and perhaps also in an emaciated condition due to a scarcity of food the previous season. Throughout the spring and early summer months frequent rains increased the normal mortality by favoring the fungous disease and by its actual mechanical action. Furthermore, excessive grassy growths in grain stubble, due to wet weather, prevented bugs from migrating from the stubble, as is usual. As a result of all these abnormally unfavorable conditions for the chinch bug, serious damage was not general, although appreciable damage resulted in a few localities, particularly in Jasper and Pulaski counties in the northwestern part of the state, and in several east central counties. Surveys have not yet been made to determine the present extent and abundance of overwintering bugs, but from all observations the past fall they are expected to hibernate in destructive numbers in most sections of the area infested in 1934, with some exceptions, notably the tier of counties bordering Illinois.

---

[1] This contribution is a continuation of an annual summary begun in 1926, with the idea of placing on permanent record the more important economic insect problems of the year. The ultimate goal in recording the problems from year to year, together with the influence of weather and other controlling factors, is a basis for predicting insect abundance and scarcity. The writer expresses his appreciation of the following who have provided records: C. M. Packard, Philip Luginbill, E. V. Walter, L. F. Steiner, G. E. Marshall, J. E. Starkey, H. K. Rippey, H. W. Gilbert, G. A. Ficht, G. E. Gould, H. O. Deay, and B. E. Montgomery.

TABLE I. COMPARATIVE MONTHLY WEATHER DATA FOR INDIANA, 1935

Month		Temperature		Precipitation		Number of Days		
		State Mean °F	Departure from Normal °F	State Average Inches	Departure from Normal Inches	Clear	Partly Cloudy	Cloudy
1934	Normal	42.4		3.05		11	7	12
November	1934	46.6	+4.2	2.87	−0.18	10	8	12
	Normal	32.3		2.88		9	7	15
December	1934	29.9	−2.4	2.00	−0.88	7	6	18
1935	Normal	29.1		3.09		10	7	14
January	1935	31.2	+2.1	2.79	−0.30	10	7	14
	Normal	30.5		2.41		9	7	12
February	1935	33.6	+3.1	1.00	−1.41	7	6	15
	Normal	40.6		3.76		10	8	13
March	1935	48.0	+7.4	5.05	+1.29	8	9	14
	Normal	51.8		3.49		11	9	10
April	1935	49.6	−2.2	2.44	−1.05	9	7	14
	Normal	62.1		4.06		12	10	9
May	1935	57.9	−4.2	7.01	+2.95	10	8	13
	Normal	71.5		3.83		14	10	6
June	1935	68.2	−3.3	4.75	+0.92	10	11	9
	Normal	75.6		3.35		16	10	5
July	1935	78.0	+2.4	3.57	+0.22	15	11	5
	Normal	73.3		3.38		15	10	6
August	1935	75.2	+1.9	3.12	−0.26	14	12	5
	Normal	67.2		3.40		15	8	7
September	1935	66.4	−0.8	2.62	−0.78	20	5	5
	Normal	54.8		2.72		15	7	9
October	1935	55.8	+1.0	1.84	−0.88	14	8	9

An unprecedented outbreak of the Hessian fly (*Phytophaga destructor* Say) occurred this past spring throughout the state with the center of most severe infestation in the central and north central counties. In some localities wheat was killed outright, as in Boone County where perhaps one-third of the wheat fields were practically destroyed. This outbreak, the first serious outbreak for perhaps twelve years, may be attributed to favorable host conditions last fall. The hot, dry summer was responsible for the shattering of much grain. This, together with the sowing of wheat ahead of the recommended date, and accompanied by moisture which insured early sprouting of grain and maximum emergence of flies, produced ideal conditions for a heavy infestation of overwintering "flaxseeds". These produced an abnormally large emergence of flies this past spring, which were sufficient to provide a heavy infestation in all sown wheat, regardless of the time it was sowed in the fall of 1934. The accompanying map (Fig. 1) gives the results of a survey made this past summer under the direction of C. M. Packard, in charge of the U. S. Cereal and Forage Insect Laboratory at Lafayette. Due partly to unfavorable weather and partly to the warnings issued by the Purdue University Agricultural Experiment Station, most wheat was sown this past fall after the "fly free" date, and we anticipate a marked reduction in fly abundance as a result.

Armyworm moths (*Cirphis unipuncta* Haw.) were commonly observed at lights at Lafayette and elsewhere the latter part of April and

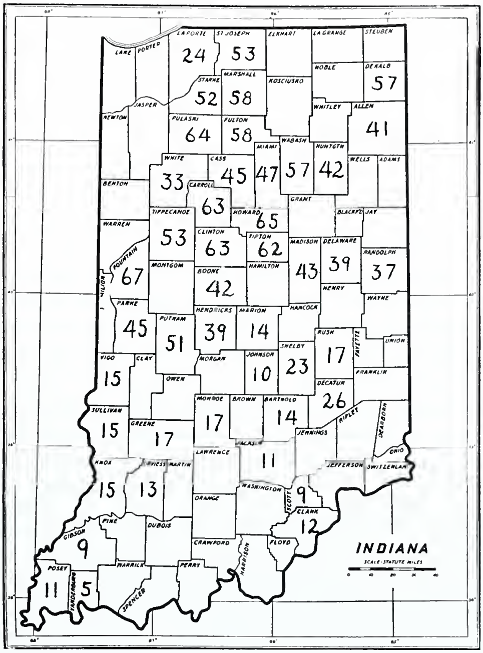


FIG. 1. Percentage of wheat stems infested, by counties, during summer of 1935, according to survey by the Bureau of Entomology and Plant Quarantine, U.S.D.A. State average for the 44 counties surveyed was 35.3 per cent.

throughout May, enabling us to predict armyworm outbreaks which later (during June) did occur in all sections of the state. In most cases the worms were attacking wheat heads, although in some cases they were damaging rye, timothy, and corn. The last report was received July 3, and all specimens sent in for identification showed a heavy tachinid parasitism.

European corn borer (*Pyrausta nubilalis* Hbn.), with favorable weather conditions for the first time in several years, made considerable headway in regaining the ground lost in 1934 because of exceptionally unfavorable conditions. The following figures, furnished by H. W. Gilbert, give a reliable index of borer increase in the northeastern region, where the species was first established in Indiana, and in a more recently infested county (Wayne). According to Ficht's observations, there appears to be a definite tendency for the one-generation borer to establish itself as a two-generation borer as it moves southward and that the borer population has increased at a greater rate distant from the region influenced by the Great Lakes. Even more than ever before, the potentiality of the corn borer as a destructive pest in the corn belt is emphasized by the observations of the past season (Table II).

TABLE II. PERCENTAGE OF HILLS PER ACRE INFESTED

County	1928	1929	1930	1931	1932	1933	1934	1935
Allen	.03	.31	.57	1.56	7.43	7.26	2.88	8.99
Dekalb	.06	.74	1.75	8.9	11.52	17.36	7.39	7.71
Steuben	.11	.67	3.31	11.01	14.34	13.39	2.14	7.15
Wayne	....	....	....	....	.969	....	.823	9.17

Corn seed maggot (*Hylemyia cilicrura* Rond.) was reported very destructive to planted corn seed in Tippecanoe, Tipton, and LaPorte counties the first few days in June. All infestations, so far as known, were found in early planted corn which did not germinate promptly because of cool, wet weather.

Cutworms were reported abundant in a few isolated localities. In one instance, at Greenfield, May 21, they damaged sweet clover.

Sod webworms (*Crambus* spp.) were destructive to corn in central Indiana, and as far north as LaPorte County, the last two weeks in June. Later in the season (late July and early August) they were damaging golf greens in several localities in the northern half of the state.

The garden or alfalfa webworm (*Loxostege similalis* Gn.) was seriously damaging young alfalfa at New Paris and Goshen, August 8. Unauthentic reports indicate a rather general and scattered infestation in the northern counties of Indiana.

Corn earworm (*Heliothis obsoleta* Fab.) which was abnormally abundant and destructive to both corn and tomatoes in 1934, was only moderately abundant in sweet corn the past season and caused scarcely any damage to field corn and tomatoes.

Corn leaf aphid (*Aphis maidis* Fitch) was exceedingly abundant on corn, especially the tassels, during August, throughout central Indiana.

The aphids were apparently responsible for infections of soft rot which accompanied and followed aphid abundance.

Wheat midge (*Thecodiplosis mosellana* Geh.) was abundant in threshed wheat at Goshen, August 13.

Clover leaf weevil (*Phytonomus punctatus* Fab.) was damaging clover at Goshen, Decatur, Fort Wayne, and South Bend, all in the northern third of the state May 14-15. At the time all specimens submitted showed mold fungus infection, and, since the weather continued wet, no further trouble was anticipated, although on May 29, this insect was reported as destructive to sweet clover at South Whitley.

Clover seed chalcid (*Bruchophagus funebris* How.) heavily infested clover seed received from a seed house at Goshen, the source of the seed undetermined. Adults began to emerge from this seed soon after it was received, June 20.

Common stalk borer (*Papaipema nitela* Gn.) was first reported from Campbellsburg on July 8, where it was damaging sweet corn. Full grown larvae were reported in corn from Marengo, August 8. These were the only reports received during the season, indicating a scarcity of the insect.

Springtails (Order Collembola) were reported as very destructive to 15 acres of alfalfa seedlings at Muncie, May 27. Details were not available.

Vegetable Insects

Mexican bean beetle (*Epilachna corrupta* Muls.) was the major insect pest of garden crops during the past season and was more abundant than usual in all parts of the state. For the first time it was reported as very destructive in the extreme northwestern county (Lake) of the state. Reports of abundance were first received in June and continued throughout the reason.

Colorado potato beetle (*Leptinotarsa decemlineata* Say) was reported abundant in several localities. At Vincennes, 30 acres of tomatoes were destroyed by the attacks of the adult beetles July 5.

Spotted cucumber beetle (*Diabrotica 12-punctata* Fab.) was common, beginning in June, in all parts of the state, especially the central area. They attacked a variety of garden crops. The larvae were common on corn roots, especially in the northern half of the state, and injury attributed by many to chinch bugs was evidently the work of these larvae.

Striped cucumber beetle (*Diabrotica vittata* Fab.) was very abundant in July and August throughout the state and was especially difficult to control because of frequent rains, requiring frequent insecticide applications.

Sweet potato beetles (*Metriona bicolor* Fab. and *Cassida bivittata* Say) damaged sweet potatoes at Connersville and Terre Haute the latter half of June.

Cabbage curculio (*Ceutorhynchus rapae* Gyll.) was apparently responsible for injury to cabbage at Nashville June 1. The insects themselves were not seen but the plants received were characteristically injured.

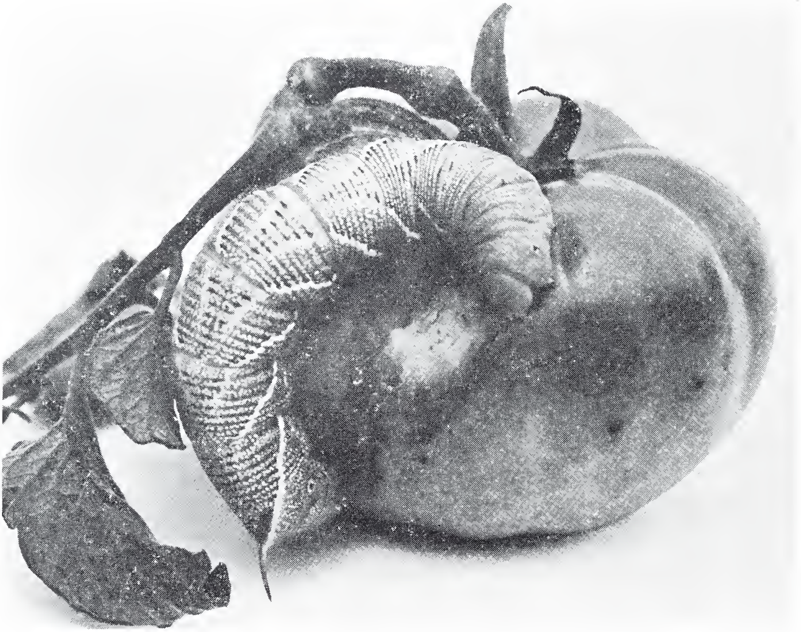


FIG. 2. Green tomato worms (*Protoparce quinquemaculata* and *P. sexta*) were unusually abundant in some regions, not only feeding on foliage, as is their normal habitat, but causing serious losses by eating into green fruits.

Rhubarb curculio (*Lixus concavus* Say) damaged rhubarb at Indianapolis and Lafayette the last of June.

Northern and southern tomato worms (*Protoparce quinquemaculata* Haw. and *P. sexta* Johan.) were very abundant in many tomato growing areas of Indiana, especially in weedy fields. In some fields near Lafayette, August 1, about 20 per cent of the green tomatoes were destroyed as a result of feeding on the fruits (Fig. 2).

Cabbage worms were unusually abundant in many sections of the state. The imported cabbage worm (*Pieris rapae* L.) was most abundant the last of July and early August. Shortly thereafter the cabbage looper (*Autographa brassicae* Ril.) became the predominant species in many localities.

Io moth caterpillars (*Automeris io* Fab.) were reported doing "considerable damage to sweet corn" at Richmond, August 12.

Cabbage maggot (*Hylemyia brassicae* Bouché) reported damaging cabbage at Bourbon, July 16.

Squash vine borer (*Melittia satyriniformis* Hbn.) damaged squash at Lagrange, June 4.

Tarnished plant bug (*Lygus Pratensis* L.) was abundant and destructive to celery and potatoes in northern Indiana, beginning the last of June and continuing until the latter part of August. According to observations by Gould, weediness of fields and surroundings is largely, if not entirely, responsible for the heavy infestations.

Potato leafhopper (*Empoasca fabae* Harr.) was normally abundant and destructive to beans in many localities during June and July. Apparently it was less destructive than usual to potatoes.

Squash bug (*Anasa tristis* De G.) was destructive at Goshen, Elkhart, and Terre Haute, during July and early August, according to reports of correspondents.

Cabbage aphid (*Aphis brassicae* L.) was especially abundant during June at Crawfordsville and Marengo and elsewhere in the state. During September it was excessively abundant on cabbage and kale in several southern Indiana localities.

Melon aphid (*Aphis gossypii* Glov.) was generally common and destructive throughout the state attacking melons and cucumbers during July.

Red spider (*Tetranychus telarius* L.) was destructive to beans and corn at Cedar Grove, June 27.

Fruit Insects

The codling moth (*Carpocapsa pomonella* L.) is still and probably will be for many years the major fruit insect problem, not only to the apple growers of Indiana, but to those of the entire United States. The abnormally high temperatures of March stimulated early development of the overwintering larvae, and pupa were found by Steiner at Elberfeld as early as March 27. At Vincennes and Orleans pupae were not uncommon April 11, and the first adults were taken in the packing house May 9, three days earlier than in 1934. At Vincennes the first moths were taken in the orchard May 8, four days later than in 1934. The first eggs did not hatch, however, until about May 30, much later than usual. The cool, wet weather, beginning in April and extending through May and June, appreciably checked the development of the first brood and was definitely unfavorable to this brood of worms, so much so, in fact, that growers secured excellent control of the first brood worms. Although the weather was unfavorable to the codling moth, the scarcity of first brood worms in the fruit cannot be attributed to that fact alone. There is every reason to believe that the growers placed greater emphasis on the first brood sprays, and in addition there was a more general use of oils to increase adhesiveness of the arsenates, which in itself materially aided in worm control. There was a noticeable increase in the codling moth population during the second brood but the better commercial growers completed the season with very good control of this pest.

Oriental fruit worm (*Grapholitha molesta* Busck) was unusually abundant and severe the past season, resulting in very heavy infestations in marketed peaches. Our records show that the first adults appeared in the packing house at Orleans, April 25, but emergence and egg laying were checked by cool weather. However, by the latter part of May twig injury was common in southern Indiana, at which time the worms were half grown or older. Thereafter weather conditions were favorable for the development and increase of the insects.

Climbing cutworms (species?) were reported damaging apple buds at Notre Dame, June 4.

Cecropia larvae (*Samia cecropia* L.) defoliated unsprayed two-year-old apple trees at Silver Lake the first of August. The yellow-necked caterpillar (*Datana ministra* Dru.) defoliated unsprayed young apple trees at Marion August 26. Such occurrences are not unusual, which emphasizes the importance of occasionally spraying trees even before they start to bear.

The green June beetle (*Cotinis nitida* L.) was reported abundant in a number of localities in southern Indiana, and at Terre Haute, on July 23, they damaged nectarine fruits.

Japanese beetle (*Popillia japonica* Newm.) which was first taken in Indiana at Indianapolis last year, was again taken in somewhat greater numbers in the same city. No records of its occurrence in Indiana outside of Indianapolis were taken.

Cherry and pear slug (*Eriocampoides limacina* Retz.) skeletonized cherry and pear in a number of localities, being especially prevalent in the northern half of the state.

Each year we receive reports of abundance and damage by the common peach tree borer (*Aegeria exitiosa* Say), although such reports are isolated and usually not in commercial orchards. The paradichlorobenzene treatment is so completely satisfactory and has been so generally adopted by commercial orchardists, that by such growers the peach tree borer is no longer feared.

Shot hole borer (*Scolytus rugulosus* Ratz.) was reported very destructive to peach and cherry in several regions of the state.

Flat-headed borer (*Chrysobothris femoratus* Oliv.) was a serious pest of hard maple and apple in many localities throughout the state, more especially in the northern half. In fact, there is no doubt that it has been more severe than for many years. The severe heat and drought of 1934, resulting in more sun scald than usual, was probably an important factor. Gilbert writes that this borer has been a real problem to the nurserymen of northern Indiana, attacking especially apple.

San Jose scale (*Aspidiotus perniciosus* Comst.) appears to be on the increase in apple and peach orchards in all parts of the state but especially in northern Indiana. Although seasonal conditions in southern Indiana are more favorable to the increase of this scale, the notable increase in the northern part of the state may be attributed to lack of insecticide control in contrast to southern Indiana where thorough, dormant spraying is now recognized as essential to prevent increase and damage by this scale.

Although the 17-year cicada (*Cicada septendecim* L.) was supposed to appear in a few isolated regions the past season, only one report was received and that from near Crown Point in Lake County, June 13. In 1936 this insect will be prevalent throughout the state and presumably in large numbers.

Tentiform leaf-miner (*Lithocolletes malifoliella* Braun) which was abundant in southern Indiana about three years ago, is again building up to destructive numbers.

Small Fruit Insects

Strawberry leaf-roller (*Ancylis comptana* Froh.) occurred in destructive abundance in all parts of the state and apparently was more abundant than normal.

Grape leaf-folder (*Desmia funeralis* Hbn.) was abundant at Mount Vernon, July 23, and Greenville, August 5. Marshall reports this species as bad as he has ever seen it in the vicinity of Orleans.

Grape leafhopper (*Erythroneura comes* Say) was abundant on grape at Jasper, August 14.

Grape berry moth (*Polychrosis viteana* Clem.) was fairly abundant in several sections.

Raspberry cane borer (*Oberea bimaculatus* Oliv.) was unusually abundant and destructive at Fort Wayne, August 28.

Dark-sided cutworms (*Euxoa messoria* Harr.) caused considerable damage in black raspberry plantings in northern Indiana.

Currant aphid (*Myzus ribis* L.) was abundant at Marion, May 21.

Boxelder bugs (*Leptocoris trivittatus* Say) were reported annoying in homes early in the season, indicating that it might again be a pest. However, during the season only very few reports were received, indicating that the species was breeding in much fewer numbers than usual. However, it was reported attacking raspberries at Howe, July 18, where it was sucking the fruits, an unusual injury according to our observations.

Shade Trees and Ornamental Shrubs

Bagworms (*Thyridopteryx ephemeraeformis* Haw.) were quite generally abundant and destructive to arbor vitae, hard maple, boxelder, and persimmon, not only throughout its usual distribution in the southern half of the state, but as far north as Delphi and Kokomo, the most northern occurrence in Indiana on record. At Lafayette the first hatched were observed July 12, at which time they were perhaps a week old.

Catalpa sphinx caterpillar (*Ceratomia catalpae* Boisd.) has been responsible for the defoliation of many catalpa groves from Lafayette south.

Yellow-striped oak caterpillar (*Anisota senatoria* A. and S.) was unusually abundant in Starke and Pulaski counties, where it defoliated the oaks, particularly pin oak. The first reports were received the last of August and continued until the end of September.

Walnut caterpillar (*Datana integerrima* G. and R.) defoliated walnut in many localities in central and northern Indiana early in July.

Fall webworm (*Hyphantria cunea* Dru.) has been unusually abundant throughout the state, elm and boxelder in particular being attacked.

European elm scale (*Gossyparia ulmi* L.) has been reported from a number of localities in the northern half of the state. From all records there is little doubt that this scale is becoming a very serious pest of our favorite shade tree in many localities.

Cottony maple scale (*Pulvinaria vitis* L.) is apparently returning as a pest of shade trees, particularly soft maple, reports of destructiveness the past season having been received from Elwood, Frankfort, and Lawrenceburg.

Oyster shell scale (*Lepidosaphes ulmi* L.) was normally abundant on lilac, ash, and other hosts in northern Indiana.

Pine leaf scale (*Chionaspis pinifoliae* Fitch) was very abundant on Koster blue spruce at Fort Wayne, July 19, and as common on spruce and pine in other localities.

Red spider (*Tetranychus telarius* L.) was very abundant on hard and soft maples, elms, and perennials throughout the state during August.

Chalepus rubra Web. was skeletonizing linden foliage at South Bend, August 24.

A lecanium scale (*Lecanium fletcheri* Cock.) was reported by Rippey as occurring on arbor vitae as far north as the Michigan line.

Flower Garden Insects

Gladiolus thrips (*Taeneothrips gladiolii* M. and S.) was perhaps the most generally destructive flower garden pest in the state during 1935. It is now widespread throughout the state, and many of the infestations have been traced to shipments of gladiolus corms from eastern growers. Referring to his observations in the northern half of Indiana, Gilbert writes to the effect that perhaps as many as half of the "backyard" plantings of gladioli are bothered with this pest. He adds, "I feel that this pest could be brought under satisfactory control by cooperative effort on the part of all gladiolus growers, particularly the amateurs and so-called backyard gardeners. Large commercial growers effect control satisfactorily in most cases. I have never found the pest in the fields of any of the large commercial growers except one and he took measures to eradicate the pest and none were found there this year."

The tarnished plant bug (*Lygus pratensis* L.) damaged gladiclus and dahlia flowers in several northern Indiana localities. Gilbert advises that blister beetles and cucumber beetles were also damaging dahlia flowers in northern Indiana.

Leafhoppers (species not identified) are becoming increasingly destructive to Boston ivy in central Indiana. They cause an early whitening and dropping of the foliage.

Negro bug (*Thyreocoris pulicarius* Ger.) was reported attacking Buddlia at Portland, June 18. Both nymphs and adults were submitted with the inquiry.

Four-lined plant bug (*Poecilocapsus lineatus* Fab.) attacked "flower garden plants" at South Bend, June 26, the specimens received being mature.

Nasturtium aphid (*Aphis rumicis* L.) was abundant on nasturtium at Indianapolis, July 30.

Iris borer (*Macronoctua onusta* Grt.) was observed damaging iris at Noblesville, July 6, and at Lafayette and Logansport early in August.

Stalk borer (*Papaipema nebris* Gn.) damaged dahlia at Gary, September 4.

Carrot beetles (*Ligyrus gibbosus* De G.) were reported from Goshen, June 26, and LaPorte, July 6, attacking the roots and underground stems of flower garden plants, sunflower and marigold being specifically mentioned.

Household, Annoying, and Miscellaneous Pests

Termites (*Reticulitermes flavipes* Koll.) continue to be one of the major pests in Indiana. Day after day dozens of inquiries are received about this insect which is almost certainly one of the ten most destructive and most widely distributed pests in the state.

Powder post beetles (*Lyctus* sp.) were frequently reported from many parts of the state as attacking joists of buildings and timbers of log cabins.

Bedbug (*Cimex lectularius* L.) was reported on numerous occasions and from many places. Several of the reports referred to heavy infestations in poultry houses.

Common cat or dog flea (*Ctenocephalus felis* Bouché) has been quite common throughout the state, judging from the frequent inquiries received. In one case a party reported in person relative to a flea infestation in Daviess County. The fleas caused welts the size of one's thumbnail, which literally covered his body. The species was identified as the human flea (*Pulex iritans* L.).

Punkies (*Culicoides gutteipennis* Coq.) were reported exceedingly annoying at LaPorte, May 16, the insects having first appeared this year early in May. The correspondent stated that the same insect was very annoying a year ago.

Chiggers (*Trombicula* sp.) were annoying in many regions during July, especially in the southern part of the state.

Oats bug (*Anaphothrips striatus* Osb.) was unusually abundant and annoying as a human pest during July. It was common throughout the state but seems to have been more conspicuous in central and northern Indiana.

Saddle-back caterpillar (*Sabine stimulae* Clem.) was reported during the last of August and early September as occurring on pear and corn and causing irritation by "blistering the skin." Several reports from widely separated regions of the state were received.

Hag moth (*Phobetron pithecium* A. and S.) was reported from Paoli, September 4, as occurring on apple. The report stated that one of the apple pickers was "rendered in a serious condition" from the poisonous hairs of the caterpillar.

Silverfish (*Lepisma saccharina* L.) were frequently reported as annoying and in some cases as attacking wall paper and labels.

Cockroaches (*Blattella germanica* L., *Blatta orientalis* L. and *Periplaneta americana* L.) have been the subject of many inquiries from every section of the state.

Clothes moth (*Tinea pellionella* L.), carpet beetle (*Attagenus piceus* Oliv.) and buffalo beetle (*Anthrenus scrophulariae* L.) were the subject of constant inquiries. The larvae of the buffalo beetle, although doing little damage according to our observations, are the subject of frequent inquiries in the fall. In several instances the larvae of the carpet beetle were reported as infesting felt insulation between floors.

Cigarette beetle (*Lasioderma serricorne* Fab.) has been frequently reported as breeding in the "stuffing" of furniture, and the emerging beetles are reported as annoying.

Indian meal moth (*Plodia interpunctella* Hbn.) caused severe losses to dry cereal dog food at Richmond during August.

Ants of various species infesting homes and lawns were the subject of many inquiries.

House fly (*Musca domestica* L.) and mosquitoes (Culicidae) were perhaps more abundant than for several seasons in most regions of the state.

The black widow or hour glass spider (*Latrodectes mactans* Fab.) was the subject of an unusual number of inquiries the past season, many specimens being received from many places south of Indianapolis. Rippey reports finding the species at Anderson, our northernmost record during the year. At Orleans, Merle Troth took over 220 from apple baskets which had remained in his orchard over night.

Horse flies (Tabanidae) were much more abundant at Orleans, according to Marshall.

Screw worm (*Cochliomyia macellaria* Fab.) caused considerable damage at Orleans, according to Marshall.

Honeybee Situation

J. E. Starkey, State Apiary Inspector of Indiana, has furnished the following information regarding beekeeping conditions during the past year:

Bees generally wintered well. The usual losses due to lack of care in providing the necessary fundamental factors in colony condition were noted. Early spring weather conditions interfered with colony manipulation and proper care and prevented the bees from getting their due share of the nectar in the early flowers. Only the strongest colonies were valuable for pollination under these conditions. In spite of the cool, cloudy weather in May and June, the overwintered colonies continued to build up in excellent shape where the food chambers were well stocked with honey and pollen, but the great number of cool, cloudy days kept the bees inside their hives, leading to a congestion of the brood nest, which brought about the most serious epidemic of swarming experienced in a number of years. Where there was a shortage of stores or excessive swarming, the clover honey flow caught colonies on the down grade or too weak to harvest a complete crop.

The honey crop in the state is estimated to be only about 50 per cent of the normal. The drought of 1934 had killed or greatly reduced the clovers in many sections of the state, particularly in the western part. Due to soil or weather conditions, or to a combination of factors not well understood, sweet clover and other chief nectar bearing plants did not bear the usual amount of nectar even where there was an abundance of bloom in the pastures. The flow was short. Much of the honey stored by the bees was thin, and in many regions where any comb honey was produced, the excess moisture or wild yeast stored in combs caused a bursting of the cappings or a "weeping" condition which spoiled its appearance and market value. Early extracted honey had a tendency to ferment in the containers if not well ripened before extracting and if not sterilized as soon as extracted.

The fall flow was generally sufficient to insure ample winter stores to carry the bees over into the season of 1936. A good crop of surplus fall honey of excellent quality consisting of buckwheat, heartsease, Spanish needle, goldenrod, and other fall sources was reported from the northwest section of the state.

The amount of American foulbrood found by state inspectors during the season was somewhat reduced, or 6.6 per cent.

VULTURES IN INDIANA

AMOS W. BUTLER, Indianapolis

There are two species of vultures in Indiana. Observing people in the southern part of the state know both of them. One they call the turkey buzzard. It is not a buzzard but the turkey vulture. The other they call the carrion crow. It is not a crow but the black vulture. (Fig. 1).[1]

The black vulture (*Coragyps atratus atratus*) is resident in the counties along the Ohio River and ranges north almost to the National Road; it is accidental in Allen County and in southern Michigan.

Audubon (Birds of the United States of America, Text Vol. 2, 1834, p. 4) gives its range in this region thus: "continues the whole year in Kentucky, Indiana, Illinois and even in the State of Ohio as far as Cincinnati." After his account appeared, almost a half century passed before anything was again recorded of it in this region.

The next record, in Ohio, appears to be by Dr. Frank W. Langdon, near Cincinnati, December 20, 1876 (Bull. Nuttall Orn. Club., Oct. 1877, p. 109). The next record from Indiana was of two birds at Brookville, May 17, 1879, by Edgar R. Quick (Journ. Cin. Soc. N. H., Dec. 1881, p. 341).

Had they disappeared from this range for almost fifty years? Since the above dates they have been reported almost every year. They reached north as far as the counties of Knox, Monroe, Decatur, Orange, and Franklin by 1890, Morgan 1894, Putnam 1896. Reports indicate no change in many succeeding years. They were reported breeding in *Knox and *Gibson counties, where they had become common in 1895. In 1889 they nested near *Brookville, Franklin County (Butler, Birds of Indiana, Rept. State Geologist 1897, p. 768). In the winter of 1926-27 they were reported in numbers in *Jefferson County. McKim C. Copeland reported about 150 wintering in Clifty Falls State Park. A few stayed through the summer to nest.

November 12, 1934, while riding along the eastern edge of Clifty ravine, near Madison, Indiana, I was astonished to see on the opposite wall of the cliff a large number of vultures sunning themselves among the rocks and shelters. Most of them were perched on trees and rocks, some with wings outspread in the characteristic vulture way. Some were flying. I estimated that 150 birds were in sight. At least three-fourths of them were black vultures; the remainder were turkey vultures (*Cathartes aura septentrionalis*). So far as I have been able to learn, there is no other place in the Ohio Valley where so many of these birds congregate in winter. The number reported there in recent years varies from 150 to 500 in different winters. Miss Edna Banta, who was a nature guide in the park for three years, said they were common in the winter of 1927-28, but in March they began to scatter. At least one pair nested each year she was there, and she saw young learning to fly. Some persons tried to drive them away by shooting. A C.C.C. Camp was later located near-by, and now one does not see so many of the birds. S. E. Esten, with the State Conservation Department, reported numbers of vultures there in winter and estimated ninety per cent to be black vultures. That is also the report of John C. Kirkpatrick. He says these birds were first noted in Jefferson County about ten years ago (1925) near Riker's Ridge. In 1931 they were abundant in Clifty Falls State Park, roosting in winter under the ledges by "dead man's trail"; but in summer they are not common. A nest was seen among a pile of rocks near the falls in 1933, and several young were observed in the park early in September. Floyd S. Carpenter, Louisville, Ky., reported them there in numbers in the winters of 1932, 1933, and 1934. He also reported one at the State Forest in Clark County, December 16, 1934. They occur in Clark County practically every month of the year; they are also reported there by Mrs. Genevieve B. Myers and S. E. Perkins III. April 28, 1935, Mr. Carpenter observed at "Buzzard's Cave" near Tobacco Landing, Harrison County, two black vultures and fifteen turkey vultures. That is regarded as a nesting place.

---

*Indicates nesting records.

[1] This figure is published through the courtesy of Professor William P. Allyn, of Indiana State Teachers College. It was previously used to illustrate an article in the Teachers College Journal (**6**:113. 1934), from which the following (p. 114) is quoted: "Of some nine nests under observation during 1933, only two were of the black species. The specimens shown in the photographs were taken at Hoosier Highlands from the caves about the rock cliffs. The black vulture is somewhat the smaller of the two, with a black head, black body, and ivory-colored shafts in the primaries. The turkey vulture is turkey-brown in color and has a red bald head as an adult."

Frank N. Wallace found a nest containing one egg and one young among the rocks in *McCormick's Creek State Park in 1935. Both Prof. Wm. P. Allyn of Terre Haute and Clyde Volkers report them having nested for the past four years in *Putnam County (Allyn, Journal Indiana State Teachers' College, v. 6, 1934, p. 114, and Indiana Audubon

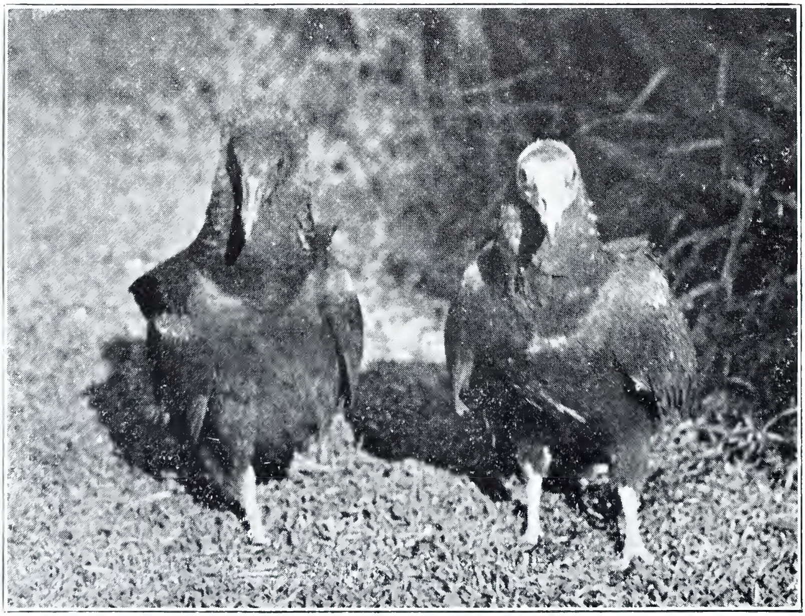


FIG. 1. Vultures in adult plumage (black vulture at left).

Soc. Year Book, 1935, p. 19). Prof. Allyn says he found them nesting at "Hoosier Highlands" in that county each of the past four years. He brought young of different ages home with him and says they make interesting pets, one of which, taken this year, he still has. These young, he says, stay in the nest from eight to ten weeks, which would indicate that their nesting probably began in May.

C. W. Brown, Vevay, Switzerland County, reported them there the past two years. Charles K. Muchmore, Laurel, Franklin County, found January 8, 1935, twenty-five black vultures in the center of a wooded tract lying between the old canal and the Whitewater River two miles south of that town. They were still there January 28, and evidently they had roosted there for some time. Later he found about the same number in woods north of Laurel. In a recent letter he says he found 44 in about the same locality in Fayette County, October 23, 1935. They have been about all summer, and, while he believes they bred, he did not find a nest.

The black vulture has also been reported from the following counties: Jackson, R. J. Fleetwood; Morgan, John Harris; Orange, Hurst Shoemaker; Knox, Roy Chansler, Clyde E. Swope.

In the bird records of the late Charles A. Stockbridge of Fort Wayne, Indiana, occurs this memorandum: "Black Vulture, May 3, 1914, Flock of 20". There is in his collection presented to the local Historical Society, a specimen labeled "Ft. Wayne", but having no date. (Esten, Ind. Audubon Soc. Year Book, 1935, p. 75). Mrs. Etta S. Wilson reported three of these birds near Tecumseh, Michigan, October 1, 1924 (The Auk, 1925, p. 442).

Prof. L. E. Hicks says they have been found nesting in the following Ohio counties: *Adams, *Scioto, *Highland, *Ross, *Lawrence, *Jackson, *Vinton, *Hocking, and *Fairfield. Stragglers in winter or in migration have been seen north to the counties: Montgomery, Franklin, Knox, and Monroe. They are resident in the southern Ohio counties but nowhere have they been reported in winter in such numbers as have been found in Jefferson County, Indiana.

The northern range in Ohio seems to be about the same as in this state. We can now say that the black vulture in Indiana ranges north to about the National Road, or Fayette and Putnam counties. They breed throughout their range. In winter, at times associated with turkey vultures, they gather in large numbers in quiet, protected places. Only one record for northern Illinois is given. (Birds of the Chicago Region, p. 31, 1934).

The turkey vulture (*Cathartes aura septentrionalis* Wied) is the one you know best. It was described by Prince Maximilian of Wied from a specimen taken near New Harmony, Indiana. The type specimen is unknown. When the Smithsonian Institution some two years ago wanted a specimen from the type locality, Dr. Herbert Friedman appealed for help, and Mrs. Louise M. Husband and Mrs. Nora C. Fretageot of New Harmony, with the help of Norman Conyers, obtained it. The specimen proved to be, as was expected, typical *septentrionalis*. It is present there throughout the year. Its range includes Indiana, Ohio, Illinois, and southern Michigan, the bird breeding throughout that range and wintering, usually, in the southern part of it. It is rare in northwestern Indiana, especially north of the Kankakee. In 1934 there are given three records from that territory (Birds of the Chicago Region, Edw. R. Ford, Colin C. Sanborn, and C. Blair Coursen, 1934, p. 31). Edw. R. Ford reports it (1929) from Lake County, Indiana, on the authority of Dr. Lewy. J. G. Parker, Jr., reports that he has often observed it at Kouts, Starke County (Birds of Indiana, 1897, p. 767).

---

*Indicates nesting records.

Ned Barker says it occurs and nests along the Kankakee in *Newton County. Archie T. Wilson gives it as a rare summer visitor—one reported July 13, 1935. Prof. C. W. G. Eifrig noted three at Tremont, Porter County, July 4, 1917 (Proc. Ind. Acad. Sci., 1918, p. 290). Chas. H. Reider also reports it from Valparaiso, Porter County, January, 1935. S. E. Perkins III gives four Starke County records, August 17 and September 27, 1934, and March 27 and September 7, 1935. Mr. Perkins also gives the following records: Marshall County: 1925, July 21, September 12; 1929, August 10; 1934, August 3, 14, September 3; 1935, March 27; Cass County, July 15, 1933; Fulton County, flock of 80 seen soaring six miles south of Kewanna, September 3, 1934. They have been recorded in the following counties: *Posey, Harrison, Clark (present practically every month), *Jefferson, Switzerland, *Franklin, Brown, Monroe (H. T. Gier), Orange, Jackson (remaining mild winters, Fleetwood, Am. Mid. Nat., Jan., 1933, p. 19); Knox, *Putnam, *Parke ("Buzzard's Roost"), *Marion (Jan. 7, 1935, Lawrence Allison), Montgomery, Delaware (S. R., Apr. 11 to Oct. 19, H. A. Zimmerman I. A. Year Book 1931, p. 46), Wayne (Feb. 26, 1935; Jay 3, May 5, 1935), Tippecanoe (not common, Dr. L. A. Test), *Wabash, *Wells; Allen (May 15, 1910, Stockbridge, Ind. Aud. Soc. Y. B., 1935, p. 75). Although scarce north of the Kankakee, these birds may reach northeastern Indiana and Michigan by way of the Wabash River. They are reported as wintering in Calhoun County, Michigan, Dec. 22, 1929 (The Auk, Apr., 1930, p. 251) and nesting at Ann Arbor, Mich., Mar. 24, 1935 (N. A. Wood). A western form, *teter*, ranges east to southern Wisconsin and south and south-central Michigan (H. Friedmann, epist.).

The distribution in Ohio corresponds to that indicated for Indiana. Milton B. Trautman (Birds of Ohio, Bull. Ohio Dept. Agr. 1:6) gives it "common summer resident, nests locally." Probably, as in Indiana, it nests more or less frequently locally throughout its range.

The food habits of both species are similar. They are essentially scavengers. They eat carrion and also fresh meat and insects and other objects. In warmer parts of America they are the chief sanitarians. We shall probably see still further extension of the range of one, if not both of these birds. Their association with Clifty Falls should be an added attraction to the State Park if they are properly protected by the authorities. They should be recognized as an asset by the Department of Conservation.

---

*Indicates nesting records.

THE OCCURRENCE OF UNUSUAL RHOPALOCERA IN INDIANA

FRED T. HALL, Crawfordsville

The occurrence of a new species of butterfly in a given region may be accounted for in one of three ways:

First, it may be confined to a small area by geographical conditions to escape destruction from its enemies, or by a limitation in the range of its food plant. These insects may be common to us after we become familiar with their environment.

Second, it may be the result of a periodic change. This may be due to weather conditions, increase in the food supply, or decrease in enemies. Butterflies falling in this group may occur commonly one season and be entirely absent the following season.

Third, it may not come under either of the former conditions, and thus we consider it as an accidental specimen.

Species falling in the first class usually occur each year in the same restricted area and nearly in the same numbers.

The second appear as waves of various species of the same area, going beyond their usual range for several successive years until the frequency reaches a maximum and then recedes again. The waves seem to be in constant motion and, in general, occur from south to north, but frequently from north to south, and changes may occur from east to west or west to east. A great wave began in 1929, reached a maximum in 1932, and is still above normal. This wave brought to Indiana many southern species which were formerly very rare. A few examples are *Papilio cresphontes*, *Nathalis iole*, *Catopsilia eubule*, *Zerene caesonia*, *Terias nicippe*, *Terias lisa*, *Euptoieta claudia*, *Junonia coenia*, *Anaea andria* and *Libythea backmani.*

The third class applies to individual specimens. One may appear far from its regular range without apparent reason, but these occurrences may frequently be traced to severe storms.

August 2, 1932, a specimen of Bates Crescent-mark, *Phyciodes batesii* Reakirt, appeared and was captured locally. This species is eastern in range and should be found in our state, but no other records have been reported. Edwards gives Indiana as a portion of its range, and likewise Holland includes this state. Batchley says it is found in Ohio and should frequent the state.

On July 7, 1932, William Leavenworth and the author observed specimens of *Calephelis borealis* Gr. & Rob. Apparently this is the first time this species has been reported from Indiana. It was common until July 20 of that season in an area of about 60 acres. The following season I collected this species at Camp Rotary, about five miles from the former place from July 2 to July 30, while William Leavenworth and James Dailey collected specimens at the former place. In the summer of 1935 it appeared at Camp Rotary from June 27 to July 30 and was very common. This species, although not formerly recorded, seems to be locally common in wooded ravines along the valley of Sugar Creek. The butterflies breed in damp areas and then spread to wooded areas, where they rest frequently on the blooms of *Hydrangea arborescens*. Although this species seems to be new in the state, Edwards and Holland include the state in its range and Blatchley believes it should be found here.

An example of an accidental visitor occurred in a specimen collected within the city limits of Crawfordsville in August, 1932, which proved to be *Chrysophanus mariposa* (Reakirt), Reakirt's Copper. This specimen seems to have been collected only in the west according to Holland.

Another species which probably occurred accidentally was *Thanoas funeralis* (Scud. & Burg.). This species is little known, but its range is considered to be the southwestern states. Holland believes it to be confined to Texas and Arizona but states that little is known of its range. This species was collected from red clover within the city limits of Crawfordsville.

Although the Lepidoptera have been studied a great deal, some intensive work in Indiana should bring results in revealing other new species.

References

Holland, W. J., 1931. The butterfly book. 2d. ed. Garden City, N. Y.

Blatchley, W. S., 1891. Catalogue of the butterflies known to occur in Indiana. Ann. Rept. Ind. State Geol. **17**:365-408.

Montgomery, Robt. M., 1931. A preliminary list of the butterflies of Indiana. Proc. Ind. Acad. Sci. **40**:351-355.

SEDIMENTATION IN WINONA LAKE AND TIPPECANOE LAKE, KOSCIUSKO COUNTY, INDIANA, JULY 31, 1930, TO JULY 30, 1935[1]

WILL SCOTT, Indiana University,
and
D. H. MINER, Westport High School,
Kansas City, Missouri

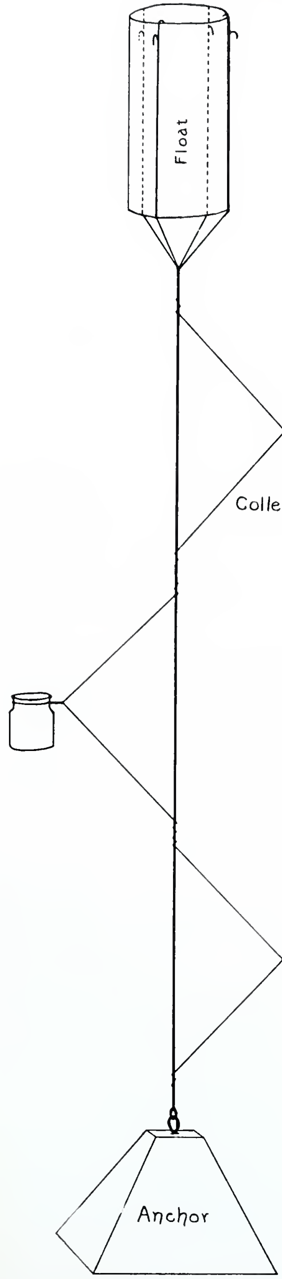


Fig. 1. Diagrammatic representation of a float with its frame and snaring hooks, an anchor, and portions of the cable with three collecting jars.

This study is an attempt to determine something of the rate and nature of the deposition on the bottoms of the lakes in northern Indiana. Lundqvist ('27) and others have shown that the deposits in many northern European lakes are laminated, and it seems pretty well established that one light band with an adjacent dark band is an annual deposit. By measuring the thickness of these bands, the rate of deposition can be determined. Welch ('35) has noted this condition in the deposits of Third Sister Lake. Fehlmann and Minder ('21) examined the sediment on the surface of a large water conduit which was submerged beneath the surface of Zurichsee and carried some distance above the bottom on a series of yokes. Below a depth of 10 meters the deposit accumulated at the rate of approximately 2 cm. per annum.

In our lakes the oligochaets and insect larvae living in and feeding on the upper part of these deposits so rework them that all traces of stratification are destroyed. The only method of attack that seemed available, therefore, was to collect the sediment at different levels in the lake as it settled out of the lake water.

A collector was designed (Fig. 1) which consisted of a wire cable with a float at one end and an anchor at the other and cylindrical glass collecting jars attached at various intervals. The weight and displacement of each part of the collector had to be carefully calculated so that the collector would be held firmly to the bottom, the cable kept taut, and unnecessary weight avoided. Detailed description of the apparatus follows.

---

[1] Contribution 248 from the Zoology Department of Indiana University.

The metal floats were all made of 16-gauge galvanized ingot iron and painted with aluminum paint. Those used in Winona Lake had a displacement of six and one-third gallons; that in Tippecanoe Lake, ten gallons. Each float was enclosed in an iron framework made of half-inch rods, and to this were welded the four snaring hooks (Fig. 1). In the beginning, oak kegs, treated with asphalt, were tried but found to be unsatisfactory. During five years of use there has not been a single failure with the metal floats.

The anchors used to hold the sediment collectors to the lake bottom were built in a mold and made of concrete with an iron ring fastened at the top. Those used in Winona Lake weighed about 125 pounds in the air, while that used in Tippecanoe Lake weighed about 133 pounds.

In each collector the float was fastened to the anchor by means of a quarter-inch galvanized iron "messenger cable" of such length that the float was held submerged at a depth of about one and one-half meters in order that there might be no trouble with boats in the summer or ice in the winter.

The jars in which the sediment was collected were fastened at the specified depths along this messenger cable, staggered with respect to each other, and held out one foot from the cable. They were held in place by brackets of No. 9 galvanized iron wire twisted around the neck of the jar and then twisted around the messenger cable. The collecting cylinders were wide necked, pint, glass fruit jars with an opening 43 sq. cm. in area and an inside height of about nine cm.

The floats used in Winona Lake produced a tension of about 31 pounds on the top and about 18 or 20 pounds on the bottom of the cable. That used in Tippecanoe Lake produced a tension of about 54 pounds against the top and about 33 pounds at the bottom of the cable. The Winona Lake collectors rested against the bottom of the lake with a force of about 55 pounds, while in Tippecanoe Lake the collector rested against the bottom with a force of about 47 pounds.

Installation of Collectors

After soundings were made at the determined locations, the collectors were put together on the lake shore. With the help of five or six people they were then carried to the boats, the anchor being placed in one boat, the float in the other, and the cable and collecting jars dragged between them. A small secondary float was attached by a cord about ten feet long to the permanent float to mark the collector's location on the surface until it could be surveyed with a transit from two reference points on the shore. Thus prepared for installation, the boats were towed to the marked location in the lake, where the anchor and float were thrown overboard simultaneously in water about one meter shallower than the final location. Then the whole apparatus was lifted and moved to the proper depth. After the location had been recorded, the surface float was removed from the permanent float.

The locations of the collectors used in Winona Lake are shown on the map (Fig. 2), and subsequent reference to them will be made by number.

The collectors were allowed to remain in position in the lakes for various periods from 10.8 months to 60 months. See Table I.

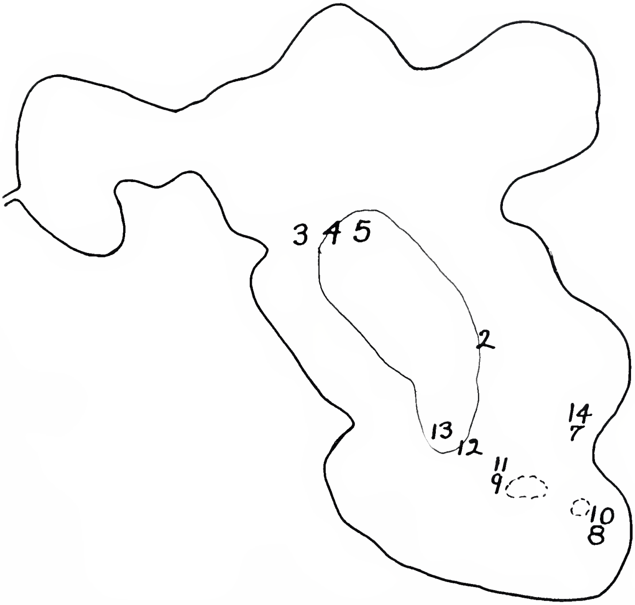


FIG. 2. Map of Winona Lake, showing locations of the collectors as numbered in the text. The sunken islands are indicated by dotted lines; the light solid line is the 22-meter contour.

Finding and Marking Collectors

When it was desired that a collector be raised for examination, its two reference lines on the shore were determined by means of the transit and marked with stakes which were visible from the lake. By rowing a boat to the point of intersection of these lines, it was possible to locate the float with a drag and to mark its position with a surface float.

Removal of the Collectors

The removal of the apparatus required a crew of at least four men. A platform was built to fit on two row boats with an open space four feet square in the center through which to raise the collectors. This apparatus was towed to the marked collector, and wires were attached to the hooks on the float. Although block and tackle was sometimes used to dislodge the weight from the bottom of the lake, it was later found that one or two men could do so without the tackle and with no great difficulty by pulling steadily. As the jars appeared at the surface, they were cut loose from the cable and covered with lids previously labeled.

Biological Analysis

Besides the materials in the jars, samples were taken from the outsides of the jars, the floats, sinkers, and supporting wires. Microscopic examinations of the fresh material were made within two to four hours after removal from the lake. In some cases, small amounts were preserved in 5% to 10% formalin, and sometimes permanent slides were made from the sediment for subsequent study.

Fresh sediment from jars at 5, 10, 15, and 20 meters in Winona Lake showed Chironomus larvae, Ciliata, creeping rotifers, moulds, rhizopods, and Algae. The Algae were given special attention, and the results are tabulated at the end of this paper.

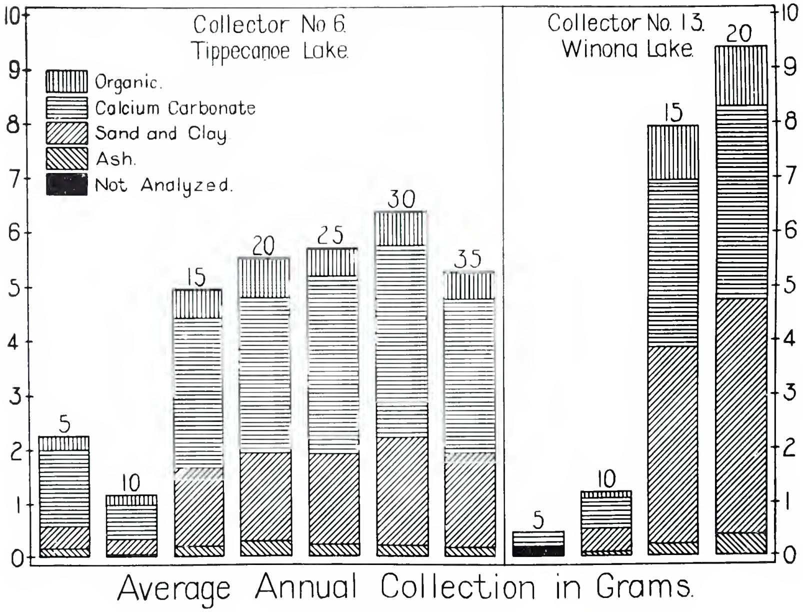


FIG. 3. See text.

Physical Analysis

After the removal of small amounts of material from the collecting jars for biological analysis, the sediment was allowed to settle for eight or ten hours. The water was then siphoned off and the sediment dried in an oven at about 60°C. for from 48 to 72 hours, when the total dry weight was determined. From this information (shown in Figure 3) Figures 4 and 5 were constructed.

Figure 4 represents a section through Winona Lake from Boys' City to Yarnell Camp, the maximum depth in this section being 22 meters. In the drawing, the depth has been exaggerated ten times. The weights of materials found at the various levels in Collectors No. 8, 9, 10, 11, 12, and 13 furnished the data for this figure.

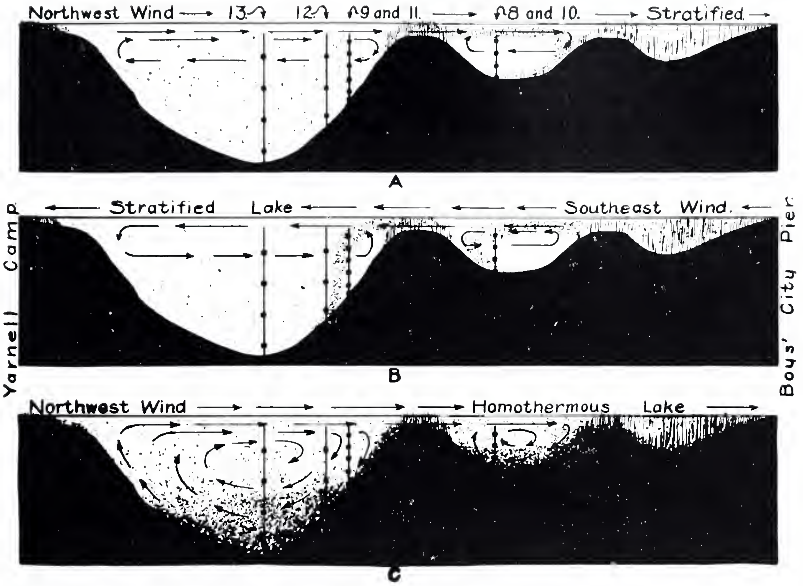


Fig. 4. Diagrams of lake circulation.

The distribution of sediment in these collectors indicates three types of condition depending on the direction of the wind and the temperature of the lake. In Figure 4, A and B indicate the way in which sediment drifts with the currents across the sunken islands, where there is much vegetation, when the lake is stratified in warm weather; C shows what seems to happen during the homothermous condition of the vernal and autumnal overturns, when the organic material and carbonates produced in the littoral are distributed generally over the lake. It must be remembered that no jars, with the exception of those on Collectors No. 7 and 14, were more than about one-fourth filled. The graphs show relative weights of material and do not give a true picture of how well filled the jars were.

Check of a Possible Error

In order to determine the probability of a loss of material from the collectors at the time of removal from the lake, the following experiment was performed. A collector jar containing 20 grams of dry sediment, and provided with a removable lid, was lowered into 40 feet of water, and the lid was removed. After one hour the jar was raised in a manner simulating the raising of one of the collectors, the water was siphoned off, and the sediment was dried and weighed. The loss was so small that it was not perceptible on a balance sensitive to 0.1 g. It is our opinion, however, that the loss from a jar of naturally deposited, flocculent sediment might be significant, especially if the total amount in the jar was less than three grams.

TABLE I

Collector Numbers	Depths of Jars	Depths of Anchors	Summer Installed	Summer Removed	Months in Water	Total Collection in Grams	Average Annual Collection	Per Cent of Carbonate	Per Cent of Organic	Per Cent of Sand and Clay	Per Cent of Ash
2	5	13.8	1930	1931	10.8	0.14	0.16	....	19.75	....	....
2	12	13.8	1930	1931	10.8	3.4	3.78	34.6	17.5	....	....
3	5	16	1930	1933	36.3	13.55	4.48	24.92	23.9	....	....
3	10	16	1930	1933	36.3	24.7	8.16	29.10	28.9	....	....
3	15	16	1930	1933	36.3	31.4	10.4	25.23	20.3	....	....
4	5	22	1930	1933	36.3	12.14	4.02	16.93	22.1	....	....
4	10	22	1930	1933	36.3	23.6	7.8	26.2	21.1	....	....
4	15	22	1930	1933	36.3	30.3	10.01	32.62	22.6	....	....
4	20	22	1930	1933	36.3	33	10.94	30.39	23.7	....	....
5	5	22.5	1930	1931	10.8	1.03	1.15	....	21.25	....	....
5	10	22.5	1930	1931	10.8	3.36	3.74	45.15	19.65	....	....
5	15	22.5	1930	1931	10.8	7.02	7.8	....	19.85	....	....
5	20	22.5	1930	1931	10.8	6.1	6.78	42.15	18.95	....	....
6	5	36	1930	1935	60	11.3	2.26	63.45	11.2	19.2	6.15
6	10	36	1930	1935	60	5.8	1.16	54.7	15.17	26.5	3.63
6	15	36	1930	1935	60	24.75	4.95	55.7	10.4	29.4	4.5
6	20	36	1930	1935	60	27.7	5.54	51.55	13.0	29.95	5.5
6	25	36	1930	1935	60	28.55	5.71	57.45	8.6	29.85	4.1
6	30	36	1930	1935	60	31.85	6.37	55.55	9.65	31.25	3.55
6	35	36	1930	1935	60	26.3	5.26	53.7	9.3	33.6	3.4
7	1	1	1930	1931	10.5	46.5	53.15	34.65	10.01	....	....
7	1	1	1930	1931	10.5	50.14	57.3	41.2	8.5	....	....
8	2½	8.5	1931	1933	25.1	23.5	11.25	44.0	18.7	....	....
8	4½	8.5	1931	1933	25.1	12.3	5.88	32.2	19.5	....	....
8	6½	8.5	1931	1933	25.1	21.6	10.33	41.4	17.1	....	....
8	8¼	8.5	1931	1933	25.1	47.1	22.6	40.65	18.6	....	....
8	8¼	8.5	1931	1933	25.1	40.3	19.3	38.0	18.25	....	....
9	2½	12	1931	1933	25.2	22.05	10.5	14.5	21.5	....	....
9	4½	12	1931	1933	25.2	29.6	14.1	14.25	5.5	....	....
9	6½	12	1931	1933	25.2	12.65	6.02	23.43	9.1	....	....
9	8½	12	1931	1933	25.2	8.0	3.81	24.75	21.9	....	....
9	10½	12	1931	1933	25.2	22.4	10.68	33.92	18.7	....	....
9	12	12	1931	1933	25.2	50.65	24.2	47.1	18.9	....	....
10	2½	8.5	1933	1935	22.2	13.7	7.4	51.9	15.55	28.4	4.15
10	4½	8.5	1933	1935	22.2	1.28	0.69	93.75	....	....	....
10	6½	8.5	1933	1935	22.2	0.15	0.08	....	....	....	....
11	2½	12	1933	1935	22.5	14.7	7.84	57.5	9.7	29.2	3.6
11	4½	12	1933	1935	22.5	1.45	0.77	71.7	....	....	....
11	6½	12	1933	1935	22.5	0.55	0.29	90.0	....	....	....
11	8½	12	1933	1935	22.5	1.65	0.88	67.8	....	....	....
11	10½	12	1933	1935	22.5	7.5	4.0	47.6	7.95	38.4	6.05
12	5	16	1933	1935	22.4	1.64	0.88	53.8	....	....	....
12	10	16	1933	1935	22.4	1.75	0.94	57.1	....	....	....
12	14½	16	1933	1935	22.4	8.51	4.55	40.5	11.4	44.2	3.9
13	5	22	1933	1935	22.6	0.85	0.45	56.0	....	....	....
13	10	22	1933	1935	22.6	2.3	1.22	45.5	9.05	35.1	10.35
13	15	22	1933	1935	22.6	14.95	7.93	38.55	12.4	45.9	3.15
13	20	22	1933	1935	22.6	17.75	9.4	37.65	11.6	46.35	4.4
14	1	1	1931	1935	47.5	113.94	28.7	30.75	5.05	59.0	5.2

Indicated depths of jars and anchors are expressed in meters.
Collector number 6 was in Tippecanoe Lake, the others in Winona Lake

TABLE II. KINDS AND RELATIVE ABUNDANCE OF ALGAE IN THE COLLECTING JARS

Collector Numbers.	2		5				7		6						
Jar depths in meters	5	12	5	10	15	20	1	1	5	10	15	20	25	30	35
No. of kinds of algae	4	5	6	6	7	9	8	11	9	8	6	9	7	8	5
Approximate abundance	7	15	8	12	18	19	13	17	16	15	13	18	16	18	14
Diatoms—															
Amphiprora	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....
Amphora	....	....	....	....	....	....	....	....	1	....	1	1	....	1	....
Asterionella	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....
Cocconeis	....	....	....	....	1	....	....	....	2	....	....	2	1	1	2
Cocconema	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Cyclotella	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Cymatopleura	....	....	....	....	....	....	1	1	....	....	1	....	....	1	....
Cymbella	....	....	....	....	....	....	....	1	....	....	....	....	....	....	....
Diatoma	....	....	....	....	....	....	....	....	....	....	....	....	1	2	....
Epithemia	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Fragilaria	....	3	....	1	3	3	1	1	1	1	1	2	3	3	2
Gomphonema	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Melosira	2	5	2	4	5	5	3	4	3	4	5	5	5	5	5
Navicula	....	....	1	....	....	1	1	1	2	1	....	....	1	1	1
Nitzschia	....	1	....	1	1	1	2	1	....	....	....	....	....	....	....
Pleurosigma	....	....	1	....	....	....	....	1	....	1	....	1	....	....	....
Stephanodiscus	1	4	1	3	4	4	2	3	2	3	4	4	4	4	4
Synedra	....	....	....	....	....	....	....	....	1	....	....	....	....	....	....
Tabellaria	....	2	....	....	3	2	2	1	....	....	....	....	....	....	....
Blue Greens—															
Anabaena	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Aphanizomenon	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Chroococcus	....	....	....	....	....	....	....	....	....	2	....	1	....	....	....
Coelosphaerium	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Gloeothece	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Gomphosphaeria	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Lyngbya	....	....	....	1	1	1	....	....	2	....	....	....	....	....	....
Merismopedia	....	....	....	....	....	....	1	....	2	....	....	....	....	....	....
Microcystis	3	....	2	....	....	....	....	....	....	....	....	....	1	....	....
Oscillatoria	1	....	1	2	....	1	....	....	....	2	....	....	....	....	....
Greens, etc.—															
Ankistrodesmus	....	....	....	....	....	....	....	....	....	1	....	....	....	....	....
Ceratium	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....
Chlorococcum	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Cladophora	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Closterium	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Coelastrum	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Cosmarium	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Crucigenia	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Mougeotia	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Oedogonium	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Pediastrum	....	....	....	....	....	....	....	1	....	....	....	....	....	....	....
Scenedesmus	....	....	....	....	....	....	....	2	....	....	1	....	....	....	....
Spirogyra	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Staurastrum	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Trachelomonas	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

1, rare; *2*, occasional; *3*, common; *4*, abundant; *5*, very abundant. Approximate abundance consists merely of the totals of the columns below.

Rusting of Wires and Cables

The collectors in Winona Lake showed very little rusting above five meters, the region ordinarily in the epilimnion. Below that the apparent rust increased slightly with the depth until within two meters of the bottom below which there was an enormous increase in the rusting.

In Tippecanoe Lake the rusting was very slight in the upper ten meters, the region ordinarily included in the epilimnion of that lake. Below that point the increase in rusting was about uniform all the way to the bottom, where it was almost as prominent as in Winona Lake. It

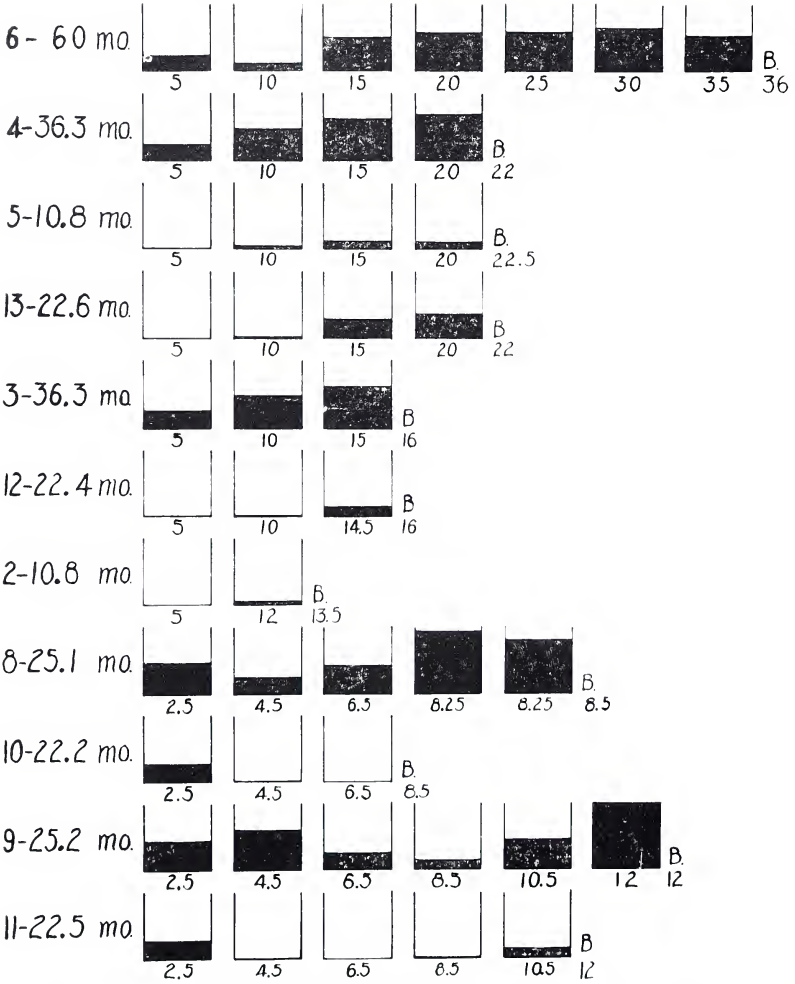


FIG. 5. Graphic representation of total weights of sediment collected. On the extreme left are the collector numbers, followed by the number of months the collector was in the lake. Under each jar is its depth in meters below the surface; under *B*, at the end of each series, is indicated in meters the depth of the lake at that point.

was noted that there was no sudden increase in the rust in the last two meters in Tippecanoe Lake.

Chemical Analysis

The following procedure was used in analyzing the sediment from all the jars on Collectors No. 6, 10, 11, 12, 13, and 14: 1. Weigh the crucible. 2. Weigh out the sample, which has been dried at about 60°C. for 24 hours. 3. Treat the sample with cold hydrochloric acid. 4. Filter and wash three times with distilled water. 5. Dry the sample in the oven for 16 hours. 6. Weigh. 7. Ash. 8. Cool and weigh. 9. Boil in hydrochloric acid for three minutes, and then boil in distilled water for three minutes. 10. Filter. 11. Dry for 20 hours, and weigh. No. 2 minus No. 6 is the weight of calcium carbonate. No. 8 is the weight of silicon dioxide and ash. No. 8 minus No. 11 is the weight of ash.

The following procedure was used in analyzing the sediment from all the jars on Collectors No. 2, 3, 4, 5, 7, 8, and 9: 1. Weigh the crucible. 2. Weigh out the sample, which has been dried at about 60°C. for 24 hours. 3. Ash. 4. Cool and weigh. 5. Boil for three minutes in hydrochloric acid. 6. Filter and wash three times with distilled water. 7 Dry in oven for 16 hours. 8. Weigh. No. 4 minus No. 8 is the weight of calcium carbonate. No. 8 is the weight of silicon dioxide and clay.

It will be noted that no account was taken of magnesium, aluminum, iron, etc. It was felt that the accuracy of collection and other methods used did not justify a determination of such salts.

Comparisons of Winona Lake with Tippecanoe Lake

There seems to be quite a difference in the method of sedimentation in these two lakes. The collections out in the pelagic regions of Winona Lake seem to indicate that there is a general mixing of sediment at some time during the year. In Figure 5, Collectors No. 4, 5, 13, 3, 12, and 2 show this rather steady increase in amount of sediment with the depth of the jar. Collector No. 6, however, shows that in Tippecanoe Lake there was only a slight increase in sediment as the depths increased. It seems that most of the sediment is formed in the epilimnion and then falls into the jars in the hypolimnion. This is also shown very well by Figure 6, which is a photograph of the jars a few hours after they were removed from Collector No. 6 in Tippecanoe Lake and before the water was siphoned off. These jars were located at depths of 5, 10, 15, 20, 25, 30, and 35 meters, starting with the left side of the photograph. They were in the lake for five years.

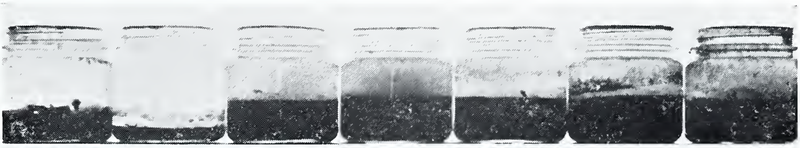


FIG. 6. See text.

This regular increase in sediment with the depth did not occur in Collectors No. 8, 9, 10, and 11 (Fig. 5). This was because they were located near the sunken islands in Winona Lake, and the currents around and over these islands brought sediments in a way that did not occur in the pelagic regions (Fig. 4).

Yearly Variations in Sedimentation in Winona Lake

Collectors No. 3, 4, and 5 were located at about one-third of the length of the lake from the north end, straight west of the center of McDonald Island and as close to the west shore as they could be to get the indicated depths. Nos. 4 and 5 were put in at the same time in almost the same depth of water and were about ten meters apart. No. 5 was removed at the end of 10.8 months. No. 4 was allowed to remain 25.5 months longer. While No. 4 was in the lake about three and one-third times as long as No. 5; its collecting jars were found to contain between five and ten times as much sediment.

This would seem to indicate that more sediment was deposited in the north part of the lake in one or both of the last two years than in the first year. The influence of the organisms growing in the sediment collected in the glass jars has not been determined. Some organisms may increase slightly the amount of sediment, while others may decrease it. An attempt is being made to eliminate this factor.

Collectors No. 8 and 10 were in practically the same location, on the southeast side of the sunken island in the south part of the lake, for approximately equal lengths of time, No. 8 being there 25.1 months and No. 10, 22.2 months. No. 10 was installed during the two years following the removal of No. 8. No. 8 collected from two to ten times as much sediment as No. 10. The same sort of comparison can be made with Collectors No. 9 and 11 on the northwest side of the same sunken island. More sediment was deposited on both sides of the sunken island during the first two years than during the last two years (Fig. 2).

The average weather conditions might cause some change in the productivity of the lake and the resulting production of sediment, but it seems that such great differences as are observed are more apt to be due to the amount, direction, and duration of the wind at certain important times of the year. For example, if, on the days when the lake happens to be homothermous, the wind does not blow, the sediment is likely to stay close to where it is formed instead of being circulated all over the lake. If there is wind at such times, its direction and strength will be important in determining the amounts deposited in various parts of the lake.

Chemical Comparisons

In Collector No. 4 the percentage of carbonate tends to increase with the depth, whereas in Nos. 12 and 13 it tends to decrease with the depth. The jars near the sunken island, with the exception of No. 9, show an irregularity in the percentage of carbonate, apparently caused by the currents coming from the island. No. 9 shows an increase in carbonate with the depth. In Collector No. 6 the percentage of carbonate collected at five meters was 63.45. Below that level the carbonate was quite uniform, averaging about 54.8%, or a decrease in percentage of about 8.65. In Winona Lake there seemed to be a large difference in the percentage of carbonate collected at the same location from one year to the next, as is shown by Collectors No. 9 and 11. The collectors located in the north part of the lake tend to show a smaller carbonate percentage than those in the south part, but more work must be done on this point to verify this tendency. It would be more significant if exactly the same method of chemical analysis had been used on the collections in both parts of the lake. The collection from Tippecanoe Lake (No. 6) shows a higher percentage of carbonate than the average of those in Winona Lake.

The percentage of organic material collected was, on the average, lower in Tippecanoe Lake than in Winona Lake. In Collectors No. 7 and 14 there was noted a relatively small percentage of organic material and a large percentage of sand and clay. The percentage of sand and clay seems to average higher in Winona Lake than in Tippecanoe Lake. In Tippecanoe Lake the percentage of sand and clay increased with the depth.

Discussion and Conclusions

The middle basin of Tippecanoe Lake, where Collector No. 6 was placed, is especially productive in plankton, with a minimum of marginal plants, due to its very steep slope. Winona Lake has a more gradual slope with dense growth of littoral plants along much of its shore line.

Our results indicate that most of the deposit in Tippecanoe Lake is formed in the epilimnion and falls directly to the bottom, with currents playing a small part in its deposition. In Winona Lake, on the other hand, much of the deposited material is derived from the littoral. If this disintegrating organic material were evenly distributed through the water of the lake during the fall overturn and then allowed to settle during the winter stagnation period, the results would be similar to those obtained in the deeper part of the lake. The results obtained near the marl shoals known locally as "sunken island" were complicated by currents carrying marl from this shoal to the adjacent deep water.

In the deepest parts of Winona Lake the sediment is being deposited at the rate of about 2.32 kg. per square meter per year, but near the sunken island the rate of deposit is about twice as great; the depth of the sediment seems to be increasing at the rate of about one-third of an inch a year in the deepest parts. These statements assume that sediment once laid down is not subsequently picked up and deposited elsewhere.

In Winona Lake there is a great deal of variation in the quantity and quality of the sediment collected at a given location from one year to the next. This seems to be correlated with the force of the wind during the periods of complete circulation.

In the deep part of Tippecanoe Lake the sediment is being deposited at the rate of about 1.4 kg. per square meter per year.

The study is being continued both in Winona Lake and lakes of different types. The apparatus here described might be adapted to the study of lake currents.

Acknowledgments

We wish to acknowledge our obligation to Dr. A. I. Ortenburger for his assistance in working out the process of chemical analysis, to Professor C. M. Palmer for his work in identifying and determining the relative frequency of the algae, to Mr. W. B. Miner for the chemical analysis of fourteen of the samples, and to the students and members of the staff at the Indiana University Biological Station, and other persons who aided in the work of installing and removing the sediment collectors.

References Cited

Fehlmann, W. and Minder, L., 1921. Beitrag zum Problem der Sedimentbildung und Besiedlung in Zürichsee. Festschrift für Zschokke No. 11.

Lundqvist, G., 1927. Bodenablagerungen und Entwicklungstypen der Seen. Die Binnengewasser II.

Welch, P. S., 1935. Limnology. New York.

THE SALAMANDERS OF PUTNAM COUNTY

A. E. Reynolds and E. G. Black, DePauw University

Indiana has had a fairly prominent role in American herpetology. especially that of a taxonomic type, yet a survey of the literature reveals little in the way of reports from Putnam County. With the intention of supplying records from this county, which we believe may well serve as a type for other counties similarly located and having the same general topography, we wish to present the first of a series of reports aiming at listing the complete herpetological fauna of the county, together with accurate studies of the diagnostic characters and habitat relations of the various species.

This paper may be considered as the first part of one dealing with the caudate Amphibia. Later reports will be made on the Salientia and Reptilia, as well as on other aspects of the present order.

Putnam County lies about 35 miles due west of the center of the state and has an area of about 475 square miles. It is generally rolling country, becoming quite level in the northern section where it borders on Montgomery County and rough and hilly in the south and west in the areas adjacent to Parke, Clay and Owen counties.

One hundred and fifty years ago the county was a primeval hardwood forest, the habitat of an abundance of wild life. Man was represented only by the aborigines whose numbers were never great, and whose mode of life did not seriously interfere with the processes of nature. Primarily they were a nomadic people, subsisting largely by hunting. Cultivation of the soil was limited to a few fields of native maize.

With the advent of civilized man into the county in the early years of the last century, all its former aspects began to change. All large and dangerous animals were destroyed or driven away. The forest was cleared and the land cultivated. Domestic animals gradually replaced wild game until now we find no large wild animals occurring, the oldest forest of second growth, and that represented only by scattered patches, and most of the land under cultivation.

These changes have greatly interfered with all native animals and their habitats. We can be reasonably sure that the clearing and cultivation of the land has brought about great changes in atmospheric humidity and moisture content of the soil. Since these factors have such an intimate connection with the habitat selection of Amphibia, we can safely assume the present-day abundance and range of any species to be but a fraction of its former extent. The dense forest was the natural home of these animals; the wood-lots and stream borders of today offer the only remaining suitable conditions to their continued existence and these only to those species adaptable to modified habitat.

Hence we find *Plethedon cinereus*, probably having greater adaptive powers than any other, by far the most abundant and exhibiting the widest range, having been taken under such widely varying conditions as are characteristic of dry watersheds and stream borders. Its relative abundance is clearly shown by a list of specimens taken from a typical salamander habitat in the county in which we find 144 individuals of this species listed, to 36 and 30 examples, respectively, of the two other most common forms.

A survey of records from 15 different localities in the county show *P. glutinosus* ranking second both in abundance and range. It seems to select a more moist habitat than *P. cinereus*, never having been taken so far from water. Consequently its range is more restricted, tending to confine it, in this county, to the above mentioned areas along streams.

P. dorsalis, usually outranked in point of numbers by *P. cinereus* in a ratio of at least 25 to 1, might be said to have the same general habitat as *P. glutinosus*, though it is probably capable of living in drier situations, comparing favorably with *P. cinereus* in this respect.

The members of the genus Eurycea, occurring in this county, namely *E. bislineata*, *E. longicauda*, and *E. lucifuga*, seem to show a more definite preference for a semi-aquatic habitat than the preceding species. They are chiefly taken from the borders of small streams in the ravines draining into the major water courses, about springs, etc. *E. bislineata* is the most abundant, outranking *P. glutinosus* in many localities. *E. longicauda* and *E. lucifuga* are common only in restricted localities, the latter being the most rarely encountered of the common species of the county.

Ambystoma tigrinum is so rare that we have records of only three individuals ever having been taken in the county. These were all in moist situations. From laboratory observations, it is probable that *A. tigrinum* makes burrows in the dry season, lying in wait at the mouths of these for passing prey. It is quite capable of devouring small toads and frogs, as we have observed.

Necturus maculosus, the only aquatic species takent in the county to date, is fairly common in the larger streams where pools of still water are formed.

Thus we find that nearly all of the specimens used in compiling the data given in this paper were taken in or near the wooded areas bordering the major water-courses of the county, as it is only in such areas a suitable environment may now be found.

The data, presented below, representing observations on a number of specimens from each species taken in Putnam County, are not presented with any special claim to newness or originality. They rather represent a careful study of the specimens with a view to presenting the commonly accepted characters in fairly exact terms.

Observations were made, for the most part, under a Bausch and Lomb binocular miscroscope equipped with 5x oculars and with 3x and 6x objectives. The living animals, anaesthetized with ether, were used in making most of the studies. Etherization required about 30 to 60 seconds for small forms like *Plethodon cinereus* or *Eurycea bislineata*, while a larger form like *Plethodon glutinosus* required from one minute to one minute and 45 seconds. The animals all recovered without obvious effect and are still living. All measurements listed below are expressed in millimeters and all body weights in grams.

The correctness of our identifications has been checked on typical specimens placed in the hands of Mr. Karl P. Schmidt of the Field Museum of Natural History. Mr. Schmidt confirmed our classifications.

Specimens examined are as follows:

1. *Necturus maculosus* Rafinesque.

This large aquatic species, belonging to the perennibranchiate family Proteidae, has a ground color of chocolate brown interspersed with small white specks. In this ground color are occasional large black spots, round or oval, and 2 to 5 mm. in diameter.

The general body proportions may be visualized from the following measurements:

Length	Head	Body	Tail	Costal Grooves	Greatest Head Width	Greatest Body Width
277.2	35.3	168.0	83.0	14	36.4	34.5
345.5	36.9	201.6	107.0	14	44.3	38.0

Head and body are depressed, the head tapering dorso-ventrally so that the muzzle is fairly flat. Viewed dorsally, the muzzle is truncate, ending bluntly anteriorly. At the posterior lateral margins of the head are three paired external gills. Paired gill slits occur between the first and second, and second and third gills.

In terms of greatest head width, the body length is 4.6 in the first case listed above and 4.5 in the second. Likewise in the first case the distance between the front and hind legs is 120 mm. as against 148.1 mm. in the second.

The depressed body changes from a horizontal oval to a vertical oval behind the posterior appendages. The tail is definitely compressed.

2. *Ambystoma tigrinum* (Green).

Of all the species taken, this one has individuals exhibiting the most stout, stocky bodies and most efficient legs. The ground color is black or very dark brown. Large yellow spots, mostly oval in shape, occur on the sides and back. Ventro-laterally the dark color gives way to a yellow belly. In some cases faint dark spots occur on the belly. In both specimens measured, the legs were 61 mm. apart. Other measurements follow:

Length	Head	Body	Tail	Costal Grooves	Body Weight	Greatest Head Width	Greatest Body Width
182.3	25.0	81.5	75.8	12	37.5	20.9	23.9
197.4	22.8	86.8	87.8	12	34.8	21.0	25.0

This species belongs to the family Ambystomidae which is characterized by stout bodies, possession of lungs, presence of a ypsiloid apparatus, and absence of a naso-labial groove.

We now turn our attention to the family Plethodontidae, which by way of contrast, have slender bodies, absence of lungs, and no ypsiloid apparatus, but have naso-labial grooves.

3. *Plethodon glutinosus* (Green).

As to general proportions of individuals of this species, the body is stout, with well-developed amphibian legs. The tail is round in cross-section, the body more or less round, and the head depressed. The tail is longer than the head and body, as the following measurements will show:

Length	Head	Body	Tail	Costal Grooves	Body Weight	Remarks
148.9	15.9	64.0	69.0	14	10.4 gms.	Heaviest specimen
151.8	15.0	57.5	79.3	14	6.8 gms.	Longest specimen
125.2	14.0	48.03	64.8	14	4.87 gms.	Average of 10 specimens

The costal groove count proved remarkably constant, no variation being seen in the specimens studied.

As to color, the animal is usually described as being black with white or silvery spots. When the skin is viewed under the binocular, it appears to be overlaid with a gelatinous layer of glassy appearance, undoubtedly of a secretory nature. This layer is pitted, and immediately under the pits are seen small translucent light-colored areas devoid of black pigment. Thus the black pigment due to the melanophores constitutes a sort of "continuous phase" in which are enmeshed these small translucent areas. At intervals are found the white spots, which, under the binocular, seem to consist of patches of white crystalline material. These are due to the guanophores, or white pigment cells, which contain guanine, a substance allied chemically to uric acid (Noble, 1931, page 141).

4. *Plethodon dorsalis* (Cope).

The individuals of this species are much smaller than those of the preceding one. Comparison of the measurements above with those given here will emphasize this fact.

Length	Head	Body	Tail	Costal Grooves	Body Weight	Remarks
85.7	8.0	35.4	42.3	17	0.8 gm.	Typical large individual
82.5	8.3	36.0	38.2	17	1.2 gm.	Typical large individual
67.39	7.27	28.46	30.64	17	0.64 gm.	Average of 10 specimens

The individuals of this species have blackish-brown pigment laterally. This dark lateral strip merges into a light color ventrally, and dorsally it becomes interrupted by a band which is zigzag in shape, and reddish, brownish, or yellowish in color. The zigzag dorsal band extends from the back of the head to the level of the hind limbs and continues nearly the length of the tail as an even-edged stripe.

The tail is round in cross-section, and in length it never exceeds the length of the body and head. The body length, on the other hand, approaches the length of the tail.

5. *Plethodon cinereus* (Green).

The salamanders of this species are of the same general size as those of *P. dorsalis*, being just a trifle larger. The species exists in two distinct color phases, the light or striped and the dark or unstriped.

The striped or light phase is the typical red-backed salamander. It is characterized by an even-edged, light reddish stripe extending from the back of the head almost to the tip of the tail. This dorsal stripe interrupts lateral dark bands of dark brown color, which merge ventrally into a light-colored, mottled belly.

The unstriped or dark phase has the same grayish, mottled ventral surface, but the rest of the body has a practically uniform coloration of blackish-brown. There is no indication of a stripe. Some forms are occasionally found which might best be described as "intermediate" in color, since they have a faint indication of the dorsal stripe, and the same ground color as the unstriped phase. Measurements of both phases follow:

Length	Head	Body	Tail	Costal Grooves	Body Weight	Remarks
88.4	8.0	35.3	44.6	19	....	Large striped specimen
88.3	8.2	36.7	43.4	19	1.1 gm.	Large striped specimen
80.9	8.1	34.7	39.7	19	0.8 gm.	Aver. of 10 striped animals
85.6	8.5	35.9	41.2	19	1.1 gm.	Lge, intermediate specimen
87.0	8.0	36.0	43.0	19	0.8 gm.	Lge, intermediate specimen
81.1	8.5	36.8	35.8	19	1.1 gm.	Large, unstriped individual
79.3	8.5	32.0	38.8	19	0.9 gm.	Large, unstriped individual
76.01	8.04	32.79	35.18	19	0.74 gm.	Average of 10, both unstriped and intermediate specimens

These measurements will confirm the above statement to the effect that *P. cinereus* is somewhat larger than *P. dorsalis*. The tail is round in cross-section, and in length it approaches or equals the length of head and body. *Cinereus* has at least one, and usually two more costal grooves than does *dorsalis*.

It may be interesting to note that in one field trip to the Fern Cliffs locality, specimens of *Plethoson cinereus* were collected in the following ratio: 118 striped, 7 unstriped, and 3 intermediate.

It is deemed advisable at this point to refer to the authorities on the salamanders, especially in their statements concerning the last three types of *Plethodon* mentioned. Cope (1889) lists all three. Under the genus Plethodon Tschudi he keys *P. cinereus* (disregarding the characters of the mouth cavity) as a *Plethodon* with a cylindrical tail, 16-19 costal grooves, belly brown marbled, above plumbeous or with a red longitudinal band. He then describes under the designation *Plethodon cinereus cinereus* Green an animal that we would at once recognize as dark-phase *P. cinereus:* upper half of the body dark liver-brown, dirty whitish beneath. He then lists *Plethodon cinereus erythronotus* Green and makes the statement: "I am unable to detect any difference in structure, proportions, and general character between this supposed species and *P. cinereus.* The only difference, if any there be, is to be found in the color of the back, that of the side and belly being very much the same". He then describes the red dorsal stripe of *P. cinereus.* We may infer from the reference to the "supposed species" above that Cope had his doubts as to its rank as a species. Dunn (1923, page 165) and Pratt (1923, page 158) regard the two phases as varieties of the same species.

Cope (1889, page 138) describes under the name of *Plethodon cinereus dorsalis* Baird the species now recognized as *P. dorsalis*, with the opening statement: "This subspecies has the size and proportions of body and limbs as in *P. erythronotus*, but may be readily distinguished by the smaller number of costal grooves, shorter body, and different character of the dorsal stripe". Dunn (1926, page 162), after describing the species makes the statement: "I cannot see my way clear to do other than to recognize *dorsalis* as a full species". Pratt (1923, page 158) treats it in the same manner.

6. *Eurycea bislineata* (Green).

In common with all members of the genus Eurycea Rafinesque found in this county, this species has a compressed tail, in contrast to the round tail of the members of the genus Plethodon Tschudi. The tail is longer than the head and body.

Length	Head	Body	Tail	Costal Grooves	Body Weights	Remarks
104.1	8.0	33.6	62.5	14	1.4 gms.	Large individual
93.0	8.0	35.0	50.0	14	1.5 gms.	Large individual
87.0	7.7	34.3	45.0	14	1.3 gms.	Large individual
84.15	7.9	33.4	46.0	14	1.3 gms.	Average of 11 specimens

The ground color of the animals seems to be clear yellow. On the sides there is a lateral dark stripe which is most intensely pigmented latero-dorsally where the dark stripe is interrupted by a dorsal light stripe, dirty yellowish-white in color. A few small black spots may occur in the dorsal median line, forming a thin discontinuous band.

Our specimens conform to the characters listed by Dunn (1926, page 297) for *E. bislineata bislineata* with the exception of the costal groove count, which is 15 in *E. b. bislineata* and 14 in our species. In this respect our specimens agree with the account of *E. b. cirrigera*, and *E. b. Wilderae* Dunn, which, however, have southern ranges entirely.

7. *Eurycea longicauda* (Green).

Measurements of typical specimens are:

Length	Head	Body	Tail	Costal Grooves	Body Weight	Remarks
134.3	10.9	44.0	79.4	13	3.4 gms.	Large specimen
132.5	11.5	46.0	75.0	13	3.2 gms.	Large specimen
124.6	11.3	42.3	71.0	13	2.6 gms.	Large specimen
110.6	11.07	43.7	61.9	13	3.0 gms.	Average of 7 specimens

These measurements reveal that this species approaches *P. glutinosus* in size. However, the animal is slender and elongated, with a depressed body and compressed tail. All of the specimens studied had 13 costal grooves except one, which had 12. The length of the tail greatly exceeds that of the head and back. The sides are heavily spotted with black. These spots thin out dorsally and leave a yellow band on the back almost free of black. On the tail the lateral black spots form bars vertically placed.

8. *Eurycea lucifuga* (Rafinesque).

Specimens of this form have been found in small numbers in the county during the past two years, and three were found during the present autumn. None of these, unfortunately, were kept long enough to make exact studies, and the measurements below are given for a single preserved specimen.

Length	Head	Body	Tail	Costal Grooves	Body Weight	Remarks
132.4	13.4	44.0	75.0	14	....	....

The salamander is yellow with a distinct reddish hue; it might be said to have an orange color. Small round or oval spots of black occur on the sides and dorsum in no particular pattern or arrangement. Dunn (1926, page 342) regards this independence of the typical pattern of spotting (lateral dark band) as an indication of the advanced state of the species. The occurrence of the lateral dark stripe, leaving a dorsal light stripe free of black, is in a measure the retention of the larval pattern (Dunn, 1926, page 342; Noble, 1931, page 148). In the case of *E. lucifuga* this breaks down, and the irregular distribution of the spots bears no resemblence to such a larval pattern.

In conclusion, we wish to state that it is our intention to correlate the present paper with one in which the life histories of the preceding forms, and any others that further collecting may discover, will be discussed.

Literature Cited

Cope, E. D., 1889. The Batrachia of North America. U. S. Nat. Mus. Bull. 34.

Dunn, E. R., 1926. The salamanders of the family Plethodontidae. Smith College Fiftieth Anniversary Publication. Northampton, Mass.

Hay, O. P., 1898. The Batrachia and reptiles of Indiana. 17th Rep. Indiana State Geol. Surv.

Noble, G. K., 1931. The biology of the Amphibia. McGraw-Hill. New York.

Piatt, Jean, 1931. Herpetological report of Morgan County, Indiana. Proc. Ind. Acad. Sci. **40**:357-368.

Shelford, V. E., 1913. Animal communities in temperate America. University of Chicago Press.

——————, 1914. Modification of the behavior of land animals by contact with air of high evaporation power. Jour. Anim. Behav. **4**:31-49.

A STUDY OF SEDIMENTATION OF WINONA LAKE[1]

Ira T. Wilson, Heidelberg College

Introduction

This paper describes the distribution of the sedimentary deposits in the main body of Winona Lake (except the portion labeled Little Eagle in Figures 3 and 4) as determined by 75 borings through the accumulated organic sediment, i. e., down to gravel or sand. The borings were numerous enough and distributed in such a manner that there could be constructed not only six cross sections of the lake but also a fairly accurate contour map of the original bottom. These diagrams have made it possible to estimate the total volume of sediment in the lake and to determine its location with reference to the original shape of the lake basin. The study has thrown some light on the nature of the so-called "marl islands", mounds of sediment rising almost to the water surface. Further studies of the same type are contemplated on other and different types of lakes in the hope that more accurate and precise generalizations may be made as to the manner in which lakes fill and become extinct.

Acknowledgments

The author is indebted to Dr. Will Scott, director of the Indiana University Biological Station, for granting the use of the facilities of the station, for furnishing the special equipment for the work, for suggesting the method of drilling used, for permitting the use of the contour map of the present lake basin hitherto unpublished, for permitting the author access to his literature, and for constant suggestions and advice during the progress of the work. Acknowledgment is due also to Richard Stoner, Richard Hotz, Robert Bruce, John Niehoff, and Robert Wilson, who assisted in the field work at various times without compensation. Members of the Biological Station staff helped the progress of the work in many ways.

General Description of Winona Lake

Winona Lake is located in Kosciusko County, Indiana, near the city of Warsaw. It lies on the western border of the Packerton moraine, which is the interlobate kettle moraine between the Huron-Erie and Saginaw lobes of the Wisconsin ice sheet.[2] It is of the kettle-hole type of glacial lake. Its greatest length is 1.7 miles; it averages slightly more than .5 mile in width and is 80 feet deep at the deepest point.

Physiographically the shore line of Winona Lake is in late youth, although the youthfulness may be partly due to rejuvenation brought about by the lowering of the lake at an earlier period. A wave-cut terrace lying along the eastern shore, 5 to 8 feet above the present lake level, indicates such a condition.

Two streams, Cherry Creek and Sugar Creek, enter Winona Lake, and there is one outlet. The two marl islands near the south end of the lake form conspicuous features of the contour map (Figs. 2 and 4).

---

[1] Contribution from the Biology Department of Heidelberg College and contribution 247 from the Zoology Department of Indiana University.

[2] Malott, C. A., 1922. The physiography of Indiana. Handbook of Indiana Geology, Pt. 2. Indiana Dept. Cons. Publ. 21:59-256.

The features noted make it apparent that Winona Lake is particularly well adapted to the present study inasmuch as it offers an averge set of glacial lake conditions.

Method of Study

Location of Borings.—The borings that form the basis of the present study are numbered and their locations shown on Fig. 2. During the field work their locations were determined by the depth of water and by drilling along lines between two conspicuous points on shore that could be located on the map. These lines are labeled on the map as A-A, B-B, etc. The locations of the borings are placed along these at the depth at which they were made, as shown by the contour lines of the map.

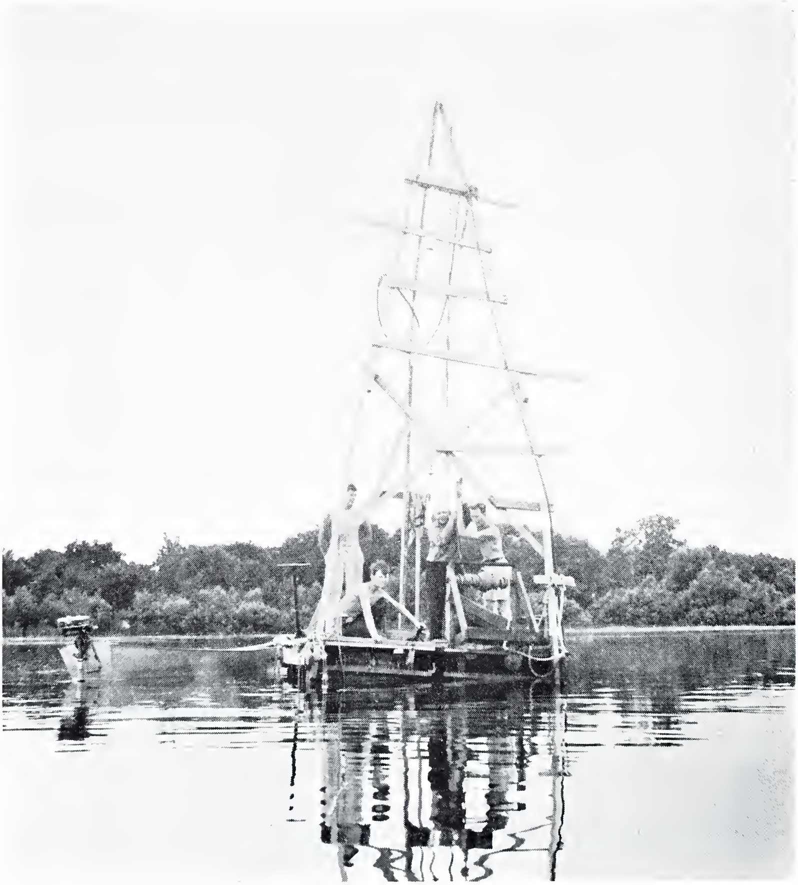


FIG. 1. The float from which drilling in water was done. The force pump is shown in the foreground at the left; the casing between the two middle figures; the tubing, with rubber hose attached, between the arms of the derrick. A block-and-tackle is shown suspended from the derrick and attached to the tubing, and a length of tubing, not in use, is shown projecting above the derrick.

The Boring Apparatus and Its Use.—The borings were made by a technique somewhat after the manner in which sulphur is recovered from wells. A casing of iron pipe, 1¾ inches in diameter, was driven into the sediment and a half-inch pipe (herein referred to as the tubing) placed inside the casing. The tubing was then connected to a force pump by a rubber hose and water was forced down the tubing to wash the sediment from the lower end of the casing. Since the casing was sealed at the bottom by the sediment, the water and sediment were forced to the top between the casing and tubing.

In the water, the work was carried on from a float (Fig. 1), which

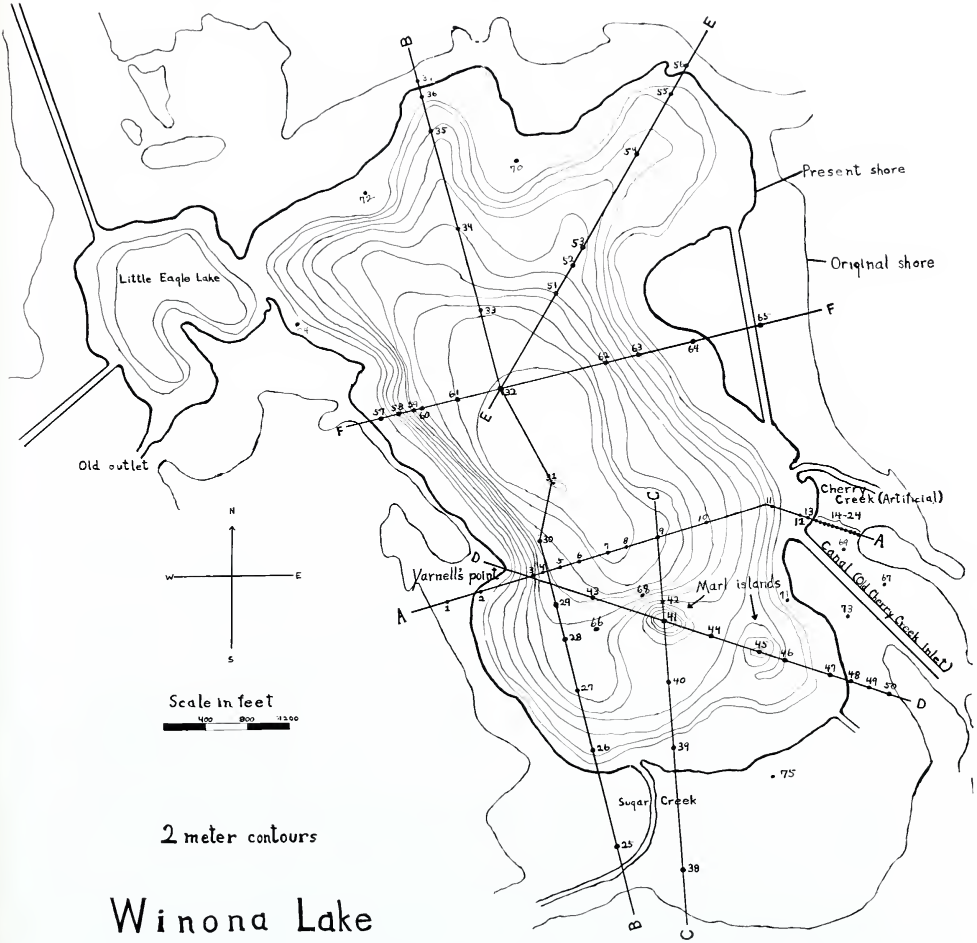


FIG. 2. Contour map of Winona Lake (made by Dr. Will Scott and hitherto unpublished), showing the lines (A-A, B-B, and etc.) along which borings were made. The numbered dots along the lines indicate the locations of the borings. The scattered borings 66 to 75 are also shown. The outermost line represents a close approximation of the original shore of the lake; it was added to the rest of the map from a map by Allen A. Norris.

was securely anchored. A derrick, block and tackle, windlass, and sometimes an automobile jack were used to facilitate the mechanical operations of lowering and raising the pipes, pulling the anchors, and many other processes. Depths were easily determined by keeping account of the amount of pipe used in the drilling operations. Holes in 80 feet of water and penetrating more than 50 feet of sediment were drilled without difficulty by this method, and no doubt it could be used for much greater depths.

Method of Sampling.—Samples of the sediment were taken at approximately 10-foot intervals in each boring. The method used to secure the samples was to put the casing down to the desired depth, then wash out all the sediment that had come up into the casing during its descent, by forcing water through the tubing as described above. When this had been accomplished, the tubing would be forced or allowed to drop into the undisturbed sediment below the casing to a distance of 2 to 5 feet, depending on the nature of the deposit, so that a plug of sediment was forced into the lower end of the tubing. Next, the tubing would be withdrawn from the casing and the sample discharged into a pint fruit jar, appropriately labeled, and sealed. This method gave ample and uncontaminated samples from a known level.

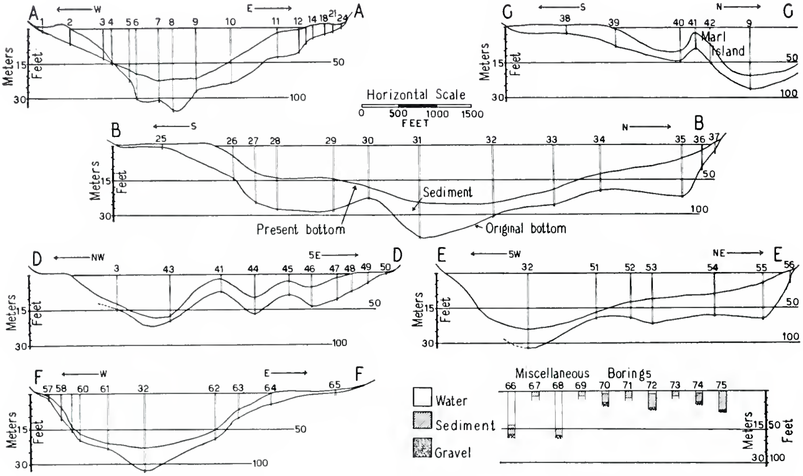


FIG. 3. Profile diagrams of the original and the present lake basins. The space between the two lines represents the sediment in the lake. The vertical scale of the diagrams is ten times the horizontal. Borings are shown as double vertical lines and numbered as in Figure 2.

It was found that the two quarter-inch holes drilled four feet from the lower end of the tubing greatly facilitated the securing of samples in the soft sediment, inasmuch as they permited the water in the lower end of the tubing to escape easily when the sample was entering instead of having to move the whole column of water. They also permitted the water above the holes and the sample to escape when the tubing was being raised in order to recover the sample. Without these holes the soft samples would be forced out by the extra pressure created by raising the tubing full of water above the lake level.

A detailed report of the mechanical and chemical analyses of the samples will be made in a subsequent paper. The samples were valuable, insofar as this report is concerned, in determining the depth of the organic deposits and the original bottom of the lake.

Field Notes.—The depth and location of each sample were recorded on a card, and these records provided the data from which the cross section profiles (Fig. 3) and the contour map (Fig. 4) of the original bottom are based.

Construction of the Profile Diagrams and Contour Maps.—In the construction of the profile diagrams and the contour maps the present water level was used as the reference point for depths of both the present and the original bottoms. The location of the six sections shown in Figure 3, together with the location of the borings upon which they are based, are shown on the contour map (Fig. 2). The locations of the borings on the profile sections are indicated by the vertical double lines labeled from 1 to 65. Both of the figures (Figs. 2 and 3) are labeled by the same letters and numbers. In order to accentuate the irregularities of the present and original bottoms, the vertical scale has been made ten times the horizontal.

In Figure 4 the contour map of the original bottom (red lines) is superimposed upon a contour map of the present bottom (black lines); the contour interval is two meters. The map of the original bottom was made by marking on the lines along which the borings were made the points where the depth was any multiple of two meters, as revealed by the profiles, and then drawing the contour lines through all points recorded for each depth. The scattered borings, 66 to 75 inclusive (Figs. 2 and 3), were of value in drawing the contour lines of the original bottom between the lines of the main cross sections.

Calculations of Volumes.—The calculations of the volumes of the present and original lake basins were made by the usual method of considering the basins as inverted cones and the contour lines as the perimeters of the bases of frustra of the cones. Since the present lake basin is 24 meters deep, it is composed of 12 frustra, while the original basin, 38.8 meters deep, is composed of 20 frustra. By tracing the contour lines on the map with a planimeter the areas of the two bases of each frustrum were determined, and the product of the average of these two by the altitude (2 meters) was regarded as a sufficiently close approximation of the volume. The sum of the volumes of all the frustra of each basin is its total volume. The difference between the volume of the original basin and that of the present basin represents the total volume of sediment, and by the same method the volume of sediment in any frustrum may be determined (Table I).

Description of Findings

General Description of Profiles and Contour Map.—The cross section profiles were located along lines (Fig. 2) which, it was thought, would best reveal the nature and shape of the original bottom; that is, they run across as many varieties of conditions as possible. For example, profiles A-A, B-B, F-F, and E-E all run from shore across or to the deep portions of the lake. The east end of A-A and the south end of B-B run across the deltas of Cherry and Sugar Creeks. Profiles C-C and D-D cross the marl islands in two directions. The miscellaneous scattered borings, 66 to 75, are located on points and in bays in such a manner as to determine whether or not the superficial conditions obtained all the way down to the original bottom of the basin. The map of the original bottom (Fig. 4) helps to visualize in three dimensions features shown only in two dimensions on the cross section profile diagrams.

An examination of the profiles and the contour maps shows that the original bottom is very much more irregular than the present bottom. In the present basin, except at the marl islands (profiles C-C and D-D), there is everywhere a progressive deepening from the shore toward the deepest part, while in the original bottom there are, besides the marl islands, many ridges between deep holes; for example, note the ridges at borings 30 and 34 on profile B-B (Fig. 3). The map of the original bottom shows five such holes (Fig. 4, A, B, C, D, and E) as contrasted with only one in the present bottom. Even where such ridges do not rise high enough to produce a hole, as in the cases referred to above, they often produce shoulders and shelves as shown best on the profiles (Fig. 3) near borings 4, 5, 7, 9, 11, and 14 on section A-A and near borings 57, 59, 61, and 63 on section F-F.

Further examination of the original bottom in the profiles (Fig. 3) and the contour map (Fig. 4) shows that, except for the marl islands, the deepest sediment occurs in the deep holes and the shallowest on the steep slopes, ridges, and shoulders, while flat places other than those in the zone of active wave action near shores and at the bottom of deep holes have an intermediate amount. For example, in section A-A the deep hole between borings 7 and 9 has 43 feet of sediment at hole 8, while on the steep slope at the west end of the section, between borings 3 and 5, where the slope is short and steep (about 3.4°), there is very little sediment,—none at boring 4. On the more gradual (about 2.5°) and longer slope at the east side of the section, between borings 9 and 11, there is an intermediate amount of sediment,—22 feet at boring 10. The same point is further illustrated along the other sections; for example, along section B-B the depths of sediment in the depressions, at borings 28 and 35, are 43.5 feet and 51.2 feet, respectively; on the ridge at boring 30 the depth is 9.8 feet; while along the gentle and longer slope between borings 32 and 34, the depth of sediment is again intermediate in amount,—21.6 feet at boring 33.

Volumes of Sediment.—The volumes of sediment in the different frustra of the lake and the total volume of sediment are shown in Table I. The total volume is seen to be 14,819,625 cubic meters. The volume of the original basin, not shown in the table, is 33,934,857 cubic meters; that of the present basin is 19,115,232 cubic meters. The volume of sediment is 43.6% of the original basin.

Distribution of Sediment.—The distribution of sediment in relationship to the original basin can be ascertained from Table I by comparison

TABLE I.—Volumes in cubic meters of the sediment in the frustra of Winona Lake when the lake is regarded as a cone divided into frustra by the contours of the original and present basins. For explanation see text.

Depth of Frustra	Volume of Sediment	Total to Level	Percentage of Total Volume of Sediment
1. 0-2 M	1,560,776	1,560,776	10.53
2. 2-4 M	1,178,160	2,738,936	18.48
3. 4-6 M	1,568,240	4,307,176	29.06
4. 6-8 M	1,499,200	5,806,376	39.17
5. 8-10 M	1,426,848	7,233,224	48.80
6. 10-12 M	1,278,808	8,512,032	57.43
7. 12-14 M	1,142,872	9,654,904	65.17
8. 14-16 M	952,020	10,606,924	71.57
9. 16-18 M	756,852	11,363,776	76.68
10. 18-20 M	611,088	11,974,864	80.80
11. 20-22 M	557,760	12,532,624	84.56
12. 22-24 M	593,000	13,125,624	88.56
13. 24-26 M	525,112	13,650,736	92.11
14. 26-28 M	377,680	14,028,416	94.66
15. 28-30 M	307,968	14,336,384	96.73
16. 30-32 M	228,736	14,565,120	98.28
17. 32-34 M	146,880	14,712,000	99.37
18. 34-36 M	78,880	14,790,800	99.85
19. 36-38 M	27,168	14,817,968	99.98
20. 38-38.8 M	1,657	14,819,625	100.00

of the totals of sediment down to any level with the total volume of sediment. This is shown in the column labeled "total to level". The column marked "percentage of total volume of sediment" indicates the relationship which the volume to that level bears to the total volume. For example, the total to the six meter level (bottom of frustrum 3) is 4,307,176 cubic meters, which is 29.0% of the total volume of sediment.

Perhaps the most valuable way to examine the distribution of sediment is to determine the contour inside and outside of which 50% of the sediment occurs and compare the area of the original lake surface outside this contour and below which 50% of the volume of sediment occurs with the area inside the contour and below which the other half of the sediment occurs. This can be referred to as the 50 percentile line or contour.

One-half the total volume of sediment in the lake amounts to 7,409-812 cubic meters. This is approximately the volume indicated in Table I from the surface down to the bottom of frustrum number 5, that is, to the 10-meter level. Since this 10-meter plane runs through the basin horizontally, it is impossible to tell from the data exactly where a projection of the vertical 50 percentile contour is, but it has to pass through the basins between the 10-meter contours of the two basins. An examination of the map showing both sets of contours (Fig. 4) shows that the 8-meter contour of the present basin lies between the two. Therefore, it can be used as a basis of calculation of surface areas of the original lake basin within and without the 50 percentile line.

Calculation of the surface area of the lake within the 8-meter contour gives 917,376 square meters. This figure subtracted from the surface area of the original lake basin (3,255,872 square meters) gives 2,338,496 square meters as the area of the original basin lying outside the 50 percentile (8-meter) contour. The last figure is 2.5 times as great as that for the area inside the 50 percentile (8-meter) contour. This means that the rate of settling inside the 50 percentile contour has been 2.5 times as fast, on the average, as the rate outside.

Marl Islands.—The profiles and contour maps (Figs. 3 and 4) show the marl islands to be accumulations of sediment on the tops of knobs or swells of the original bottom. The larger island, in fact, is an elevation at the end of a ridge of the original bottom extending on a southeasterly direction from Yarnell's point. This can be ascertained by an examination of the contour map of the original bottom (Fig. 4). The smaller marl island is built on a somewhat more isolated knob of the original bottom. The original peaks of the larger and smaller knobs were 8 and 10 meters, respectively, from the present water level. They rise 4 to 10 meters higher than the bottom immediately surrounding them. The depth of sediment on the islands is as great as or greater than that in the depressions immediately surrounding them, which is just the opposite of the condition ordinarily obtaining on ridges and in their adjoining depressions.

Uniformtiy of Depth of Sediment in the Originally Deep Holes.—There are five deep holes in the original bottom (Fig. 4, A, B, C, D, and E), some located near the original shores of the lake and some nearer the middle. The depth of sediment in the different holes is strikingly uniform. The absolute depth of the original hole apparently affects the depth of deposition very little as long as the depth is great enough to protect the sediment from the action of waves or shore currents. For example, in hole A (Fig. 4) the original depth was 26.6 meters, and the sediment 13.1 meters; in hole B the original depth was 38.8 meters, and the sediment 14.8 meters; in hole C the original depth was 21.5 meters, and the sediment 15.5 meters; in hole D the original depth was 20.3 meters, the sediment 9.8 meters; and in hole E the original depth was 16.6 meters, and the sediment 13.6 meters. These data indicate strongly that the factors which are responsible for the distribution of sediment have affected its distribution uniformly over the entire lake except in the littoral region.

Proportion of the Basin Obliterated.—As stated in the section on Volume of Sediment (p. 300), 43.6% of the volume of the original basin is now occupied by sediment. The original area of the lake, 3,255,872 square meters, minus 2,037,128 square meters, the present area of the lake, equals 1,218,744 square meters. The portion of the original lake area that is now emergent (1,218,744 sq. m.) is 37.4% of the original area. There is probably no significance to the fact that the two percentages are nearly equal.

Discussion

The foregoing facts lend themselves to the following interpretation of the origin and subsequent history of this lake:

The original basin is marked by knobs, swales, and ridges very much like those of the surrounding morainic topography. Some assortment of the bottom materials due to lake currents took place before the more typical lake sediments of carbonates and organic matter became dominant and covered the original bottom of gravel. In other words, the lake must have had a considerable history before organisms became well established. The assortment of the original bottom materials is made evident by the fact that the original ridges are covered with coarse gravel and sometimes unsorted materials and the depressions with fine sand.

When the characteristic lake sediment became sufficient to dominate the bottom accretions, it probably accumulated much more rapidly in the deep holes than on the ridges and knobs. Because of the effects of lake currents, deposition occurred only in the holes until they were filled to the level of the adjoining ridges. After the holes were filled to the level of the adjacent ridges the bottom contours were smooth and regular, and filling was probably more uniform over the whole bottom of the lake, or at least those portions where the above conditions obtained, because the currents were more uniform. This sequence of events is what one would expect from the influence of the bottom contours on the deposition of sediment, or upon its fate after it had settled, and it accounts for the fact that the accumulated sediment is now much shallower on the ridges, shoulders, and knobs than in the holes and on the relatively flat parts of the bottom. The above argument is supported by the work of Trask[3] on marine deposits; he found that currents are very effective in assorting the sediment when the depth is below the zone of active wave action.

The fact that all the five deep holes of the original bottom have almost equal depths of sediment, indicating that the rate of deposition in all the basins is fairly uniform regardless of depth, can be accounted for on the assumption that the sediment involved is so fine that it stays in suspension long enough to become very evenly distributed over the lake and settles out at a fairly uniform rate, that portion settling on the ridges being removed by currents and carried to the depressions where it settles out and remains undisturbed. It is hard to see how settling could occur at different rates over different parts of the bottom and always be greater over the holes than over the ridges. It seems to make little difference whether the hole is near the shore or distant from it, since in actual fact some of the original holes were close to shore (C and E, Fig. 4), some an intermediate distance (A and D, Fig. 4) and one (B, Fig. 4) near the middle of the lake.

To account for the fact that most of the sediment of the lake lies on the deep-water side of the shore zone, it is necessary to assume that most of the accretions of sediment along shore are abraded and ground to such fineness that they go into suspension and are distributed generally over the lake to settle out in the deep water. The unabraded sediment settles out along shore. This interpretation is made likely by the fact that the sediment in the middle of the lake averages almost 50% silicon dioxide, as contrasted with only about 10% near shore, all but 5% of the remainder of the sediment in both places being carbonates.

---

[3] Trask, Parker D., 1931. Sedimentation in the Channel Islands Region, California. Economic Geology. **26**:24-43.

The occurrence of the marl islands, with their thick deposits of sediment, 90% carbonates, on top of knobs on the original bottom, which ordinarily would be expected to have very little sediment, can be accounted for by assuming that their original peaks were near enough to the surface (8 and 10 meters), at least in the earlier and less turbid stages of the lake, to permit the lodgement and growth of vegetation, which not only contributed sediment to them at a rapid rate but furnished protection from the currents that ordinarily would tend to dislodge the accumulations. Of course, such isolated accumulations would not be submitted to the actions of the undertow and shore currents to such an extent as would similar accumulations along shore. Probably the reason that the islands are not now emergent (they are about 1½ meters below the water surface) is that, where the accumulation gets close enough to the surface to be materially affected by waves, the accumulations erode as rapidly as they form and are carried away to be deposited in deeper water.

Conclusions

A new approach to the study of the problem of sedimentation is presented by securing data making it possible to construct a contour map and cross section diagrams of the original lake basin, from which the volume of sediment can be determined. A new method of drilling and sampling is described.

The unevenness of the floor of the original basin, as compared with the present bottom, is noted, together with the apparent fact that there was considerable assortment of the original bottom material before the characteristic lake sediment began to accumulate.

The original bottom is shown to be gravel and sand.

It is apparent that although the finely abraded sediment is probably fairly evenly distributed over the lake by currents, either the rate of settling is not uniform or its final place of lodgement is dependent to a large extent on the configuration of the bottom, most of it finding permanent lodgement in the depressions, at least until the depressions are filled to the level of the surrounding ridges.

The total volume of sediment is shown to be 43.6% of the volume of the original basin; it has settled mainly in the deep water, away from the shore zone, showing that the lake is filling more rapidly in the middle than along the shore, contrary to what has often been assumed.

The "marl islands" in the lake are shown to be relatively thick deposits of sediment resting on mounds of the original bottom which rise considerably above the level of the bottom immediately surrounding them. A theory is proposed to account for the unusually heavy sedimentary deposits covering them.

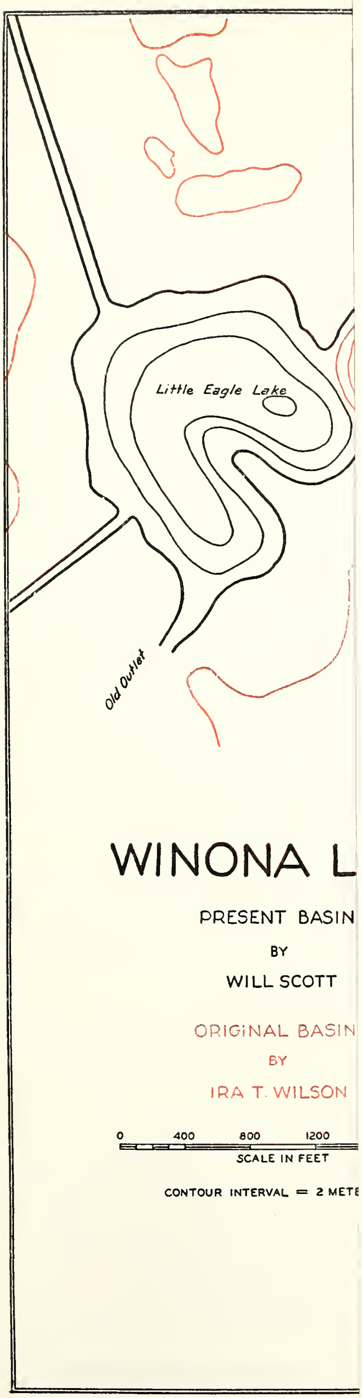


FIG. 4. A contour map of the o
of the original basin are labeled A,

on the deep-water side of the shore zone, it is necessary to assume that most of the accretions of sediment along shore are abraded and ground to such fineness that they go into suspension and are distributed generally over the lake to settle out in the deep water. The unabraded sediment settles out along shore. This interpretation is made likely by the fact that the sediment in the middle of the lake averages almost 50% silicon dioxide, as contrasted with only about 10% near shore, all but 5% of the remainder of the sediment in both places being carbonates.

The occurrence of the marl islands, with their thick deposits of sediment, 90% carbonates, on top of knobs on the original bottom, which ordinarily would be expected to have very little sediment, can be accounted for by assuming that their original peaks were near enough to the surface (8 and 10 meters), at least in the earlier and less turbid stages of the lake, to permit the lodgement and growth of vegetation, which not only contributed sediment to them at a rapid rate but furnished protection from the currents that ordinarily would tend to dislodge the accumulations. Of course, such isolated accumulations would not be submitted to the actions of the undertow and shore currents to such an extent as would similar accumulations along shore. Probably the reason that the islands are not now emergent (they are about 1½ meters below the water surface) is that, where the accumulation gets close enough to the surface to be materially affected by waves, the accumulations erode as rapidly as they form and are carried away to be deposited in deeper water.

Conclusions

A new approach to the study of the problem of sedimentation is presented by securing data making it possible to construct a contour map and cross section diagrams of the original lake basin, from which the volume of sediment can be determined. A new method of drilling and sampling is described.

The unevenness of the floor of the original basin, as compared with the present bottom, is noted, together with the apparent fact that there was considerable assortment of the original bottom material before the characteristic lake sediment began to accumulate.

The original bottom is shown to be gravel and sand.

It is apparent that although the finely abraded sediment is probably fairly evenly distributed over the lake by currents, either the rate of settling is not uniform or its final place of lodgement is dependent to a large extent on the configuration of the bottom, most of it finding permanent lodgement in the depressions, at least until the depressions are filled to the level of the surrounding ridges.

The total volume of sediment is shown to be 43.6% of the volume of the original basin; it has settled mainly in the deep water, away from the shore zone, showing that the lake is filling more rapidly in the middle than along the shore, contrary to what has often been assumed.

The "marl islands" in the lake are shown to be relatively thick deposits of sediment resting on mounds of the original bottom which rise considerably above the level of the bottom immediately surrounding them. A theory is proposed to account for the unusually heavy sedimentary deposits covering them.

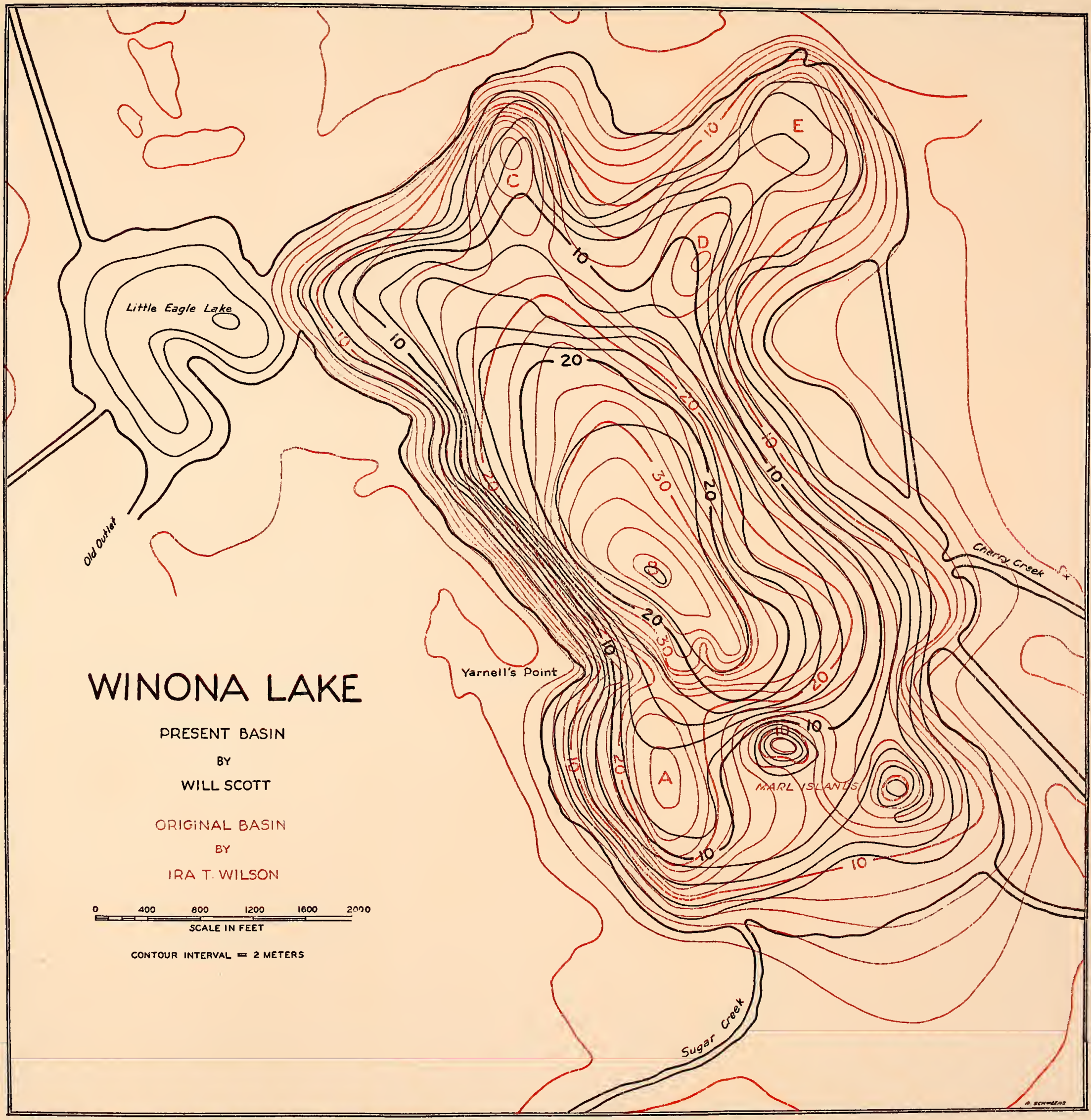


FIG. 4. A contour map of the original basin (red lines) superimposed upon the contour map of the present basin (black lines). The 5 holes of the original basin are labeled A, B, C, D, and E. The contour interval is two meters.

HEMIPTERA UNRECORDED FROM INDIANA

HOWARD O. DEAY and GEORGE E. GOULD, Purdue University[1]

Blatchley (1926 in his manual "Heteroptera of Eastern North America" records 414 species and 21 varieties of Hemiptera that occur in Indiana. Since then 26 species and five varieties have heen added to the state list by the following authors: Blatchley (1928), two species of Miridae; Drake and Harris (1934), two species of Gerridae; Esaki (1926), one species of Gerridae; Evans (1931), one species and one variety of Phymatidae; Gould (1933), one species of Veliidae; Knight (1926, 1927), one species and one variety of Miridae; Musgrave (1934), 18 species and three varieties of Miridae. In addition, there are two species reported from the state which Blatchley (1926, 1928) overlooked. These are the common box-elder bug, *Leptocoris trivittatus* (Say), reported by Baldwin as destructively abundant in 1914 and the egg-plant lace bug, *Gargaphia solani* Heidemann, reported by Davis (1926). In connection with this last species it is of interest to note that although Heidemann did not describe this species until 1914, there are specimens of it in the Purdue Entomological Collection which were taken in Posey County in 1903.

The writers in the present paper wish to add 46 species and three varieties to the list, making 488 species and 29 varieties of Hemiptera which are known to occur in the state.

The numbers in parentheses following the serial number are those of Van Duzee's "Catalogue of Hemiptera North of Mexico". The initials P. S. C. used in "collection records" indicate specimens in the Purdue Entomological Collection which do not bear a collector's label. Specimens of all the species recorded here are deposited in the Purdue Entomological Collection.

Family SCUTELLERIDAE

1 (16). *Homaemus parvulus* (Germar, 1839).

Collection records: Clark Co., June 11-13, B. E. Montgomery, P. S. C.; Harrison Co., June 27, on willow, D. W. LaHue; Jefferson Co., June 5, D. W. Brinson.

Family CYDNIDAE

2 (44). *Cyrtomenus mirabilis* (Perty, 1834).

Collection records: Lawrence Co., July 10, August 6, 13, at light, J. M. Amos; Orange Co., July 12, at light, J. M. Amos.

Family PENTATOMIDAE

3 (99). *Trichopepla atricornis* Stal, 1872.

Collection records: Wayne Co., October 13, H. Shoemaker.

4 (125b). *Euschistus tristigmus luridus* Dallas, 1851.

Collection records: Tippecanoe Co., September 7, P. S. C.

5 (....). *Thyanta accerra* McAtee, 1919.

Collection records: Tippecanoe Co., Sept. 7, October 2, 10, G. E. Gould, P. S. C.

---

[1] Contribution of the Department of Entomology.

Notes: Dr. H. M. Harris, who determined this species, states that the specimens may be a variety of *T. calceata* (Say).

Family COREIDAE

6 (357). *Jadera haematoloma* (Herr.-Schaeffer, 1848).
Collection records: Lawrence Co., July 11, at light J. M. Amos.

Family ARADIDAE

7 (378). *Aradus inornatus* Uhler, 1876.
Collection records: Tippecanoe Co., May 12, P. S. C.

8 (389). *Aradus falleni* Stal, 1860.
Collection records: Lawrence Co., June 21, at light, L. I. Musgrave.

Family LYGAEIDAE

9 (468). *Nysius thymi* (Wolff, 1804).
Collection records: Kosciusko Co., May 24, June 24, G. E. Gould; Tippecanoe Co., October 8, L. I. Musgrave.

10 (483). *Cymus luridus* Stal, 1874.
Collection records: Porter Co., Sept. 2, B. E. Montgomery.

Family TINGIDIDAE

11 (....). *Hesperotingis illinoiensis* Drake, 1918.
Collection records: Clark Co., July 30, P. S. C.

Family PLOIARIDAE

12 (....). *Empicoris winnemana* M. & M., 1925.
Collection records: Tippecanoe Co., Nov. 28, R. A. Regains.

13 (715). *Metapterus fraterna* (Say, 1832).
Collection records: Clark Co., July 16, P. S. C.; Lawrence Co., Sept. 14, at light, J. M. Amos; Tippecanoe Co., Sept. 19, on soybeans, G. E. Gould.

Family REDUVIIDAE

14 (720). *Pnirontis informa* Stal, 1859.
Collection records: Lawrence Co., July 6, L. F. Steiner; Tippecanoe Co., June 22, at light.

15 (727). *Stenopoda cinerea* Laporte, 1832.
Collection records: Clark Co., June 5, 25, P. S. C.

16 (736). *Triatoma heidemanni* Neiva, 1911.
Collection records: Orange Co., June 12, at light, J. M. Amos.

17 (....). *Zelus angustatus* Hussey, 1925.
Collection records: Morgan Co., June 28, L. I. Musgrave.

Family ANTHOCORIDAE

18 (840). *Lyctocoris campestris* (Fabricius, 1794).
Collection records: Harrison Co., Nov. 21, D. W. LaHue; Noble Co., August 14, G. E. Gould; Tippecanoe Co., May 6, 11, P. S. C.

Family MIRIDAE

19 (893). *Trigonotylus tarsalis* (Reuter, 1876).
Collection records: Kosciusko Co., August 10, G. E. Gould; Lake Co., June 4, G. E. Gould.

20 (899a). *Platytylellus insitivus angusticollis* Knight, 1923.
Collection records: Morgan Co., June 8, L. I. Musgrave.

21 (....). *Paracalocoris salicis* Knight, 1926.
Collection records: Tippecanoe Co., June 6, Musgrave & Deay.

22 (....). *Paracalocoris gleditsiae* Knight, 1926.
Collection records: Tippecanoe Co., June 6, Musgrave & Deay.

23 (....). *Paracalocoris multisignatus* Reuter, 1909.
Collection records: Tippecanoe Co., June 14, L. I. Musgrave.

24 (1010b). *Lygidae rosacea* Reuter, 1909.
Collection records: Lawrence Co., June 14, at light, L. I. Musgrave.

25 (....). *Lygus vanduzeei* Knight, 1917.
Collection records: Wayne Co., October 9, H. Shoemaker.

26 (1024). *Lygus apicalis* Fieber, 1861.
Collection records: Morgan Co., Oct. 17, L. I. Musgrave; Tippecanoe Co., Apr. 10 to Oct. 22, L. I. Musgrave, H. G. Butler, P. S. C.

27 (....). *Lygus caryae subfuscus* Knight, 1917.
Collection records: Kosciusko Co., May 30, G. E. Gould.

28 (....). *Lygus geneseensis* Knight, 1917.
Collection records: Morgan Co., June 18, on oak, L. I. Musgrave; Tippecanoe Co., June 2, on oak, L. I. Musgrave.

29 (1044). *Xenoborus pettiti* (Reuter, 1909).
Collection records: Clark Co., July 14, on willow, P. S. C.

30 (....). *Dicyphus gracilentis* Parshley, 1923.
Collection records: Kosciusko Co., Aug. 8, G. E. Gould; Wayne Co., Oct. 8, H. Shoemaker.

31 (1175⅛). *Orthotylus viridis* Van Duzee, 1916.
Collection records: Morgan Co., June 10, on willow, L. I. Musgrave; Tippecanoe Co., June 12, on willow, Deay & Musgrave.

32 (1178¾). *Noctuocoris fumidus* Van Duzee, 1916.
Collection records: Lawrence Co., July 30, at light, L. I. Musgrave.

33 (1179⅝). *Orthotylus knighti* Van Duzee, 1916.
Collection records: Kosciusko Co., June 7, G. E. Gould.

34 (....). *Reuteroscopus sulphureus* Reuter, 1907.
Collection records: Jefferson Co., July 28, on *Solanum nigrum*, D. W. Brinson.

35 (....). *Plagiognathus punctatipes* Knight, 1923.
Collection records: Morgan Co., June 10, on boxelder, L. I. Musgrave.

36 (....). *Plagiognathus dispar* Knight, 1923.
Collection records: Kosciusko Co., June 8, G. E. Gould.

37 (....). *Plagiognathus tiliae* Knight, 1923.

Collection records: Tippecanoe Co., June 12, on boxelder, L. I. Musgrave.

38 (....). *Plagiognathus negundinis* Knight, 1923.

Collection records: Morgan Co., July 10, on willow, L. I. Musgrave.

39 (....). *Plagiognathus repletus* Knight, 1923.

Collection records: Tippecanoe Co., June 26, G. E. Gould.

40 (1249). *Leucopoecila albofasciata* Reuter, 1907.

Collection records: Jefferson Co., July 5, on *Solanum nigrum*, D. W. Brinson.

41 (....). *Microsynamma bohemanni* (Fallen, 1829).

Collection records: Morgan Co., June 10, on willow, L. I. Musgrave.

42 (996). *Dichrooscytus suspectus* Reuter, 1909.

Collection records: Indiana (specimen retained by Knight).

Family GERRIDAE

43 (1289). *Gerris buenoi* Kirkaldy, 1911.

Collection records: Benton Co., G. E. Gould; Clay Co., G. E. Gould; Kosciusko Co., H. O. Deay, G. E. Gould; Warren Co., G. E. Gould. Collection dates: April 15 to October 17.

44 (1290). *Gerris canaliculatus* Say, 1832.

Collection records: Carroll Co., July 15, G. E. Gould; Tippecanoe Co., April 22, G. E. Gould.

45 (....). *Gerris comatus* Drake & Hottes, 1925.

Collection records: Elkhart, Kosciusko, Noble, Pulaski, Tippecanoe, and Warren counties. Collector: G. E. Gould. Dates: April 8 to August 11.

46 (....). *Gerris nebularis* Drake & Hottes, 1925.

Collection records: Kosciusko Co., August 8, G. E. Gould.

47 (....). *Trepobates inermis* Esaki, 1928.

Collection records: Allen, Bartholomew, Carroll, Clay, Decatur, Dubois, Huntington, Jennings, Johnson, Lawrence, Marion, Monroe, Owen, Parke, Putnam, Ripley, Tippecanoe, Wabash, and Whitley counties; all collected by G. E. Gould; Harrison Co., D. W. LaHue. Collection dates: July 4 to October 15.

Notes: Blatchley (1926) no doubt records specimens of this species under *T. pictus* (H.-S., 1848), since the two were confused until Esaki's work in 1926.

48 (1297). *Rheumatobates rileyi* Bergroth, 1892.

Collection records: Decatur and Ripley counties, Oct. 15, G. E. Gould.

Family VELIIDAE

49 (....). *Microvelia austrina* Bueno, 1924.

Collection records: Tippecanoe Co., G. E. Gould.

References Cited

Baldwin, C. H., 1914. Sixth annual report of the State Entomologist of Indiana, **1912-13**:27-30.

Blatchley, W. S., 1926. Heteroptera of Eastern North America. Indianapolis.

Blatchley, W. S., 1928. Notes on Heteroptera of Eastern North America with descriptions of new species, I. Jour. N. Y. Ent. Soc. **36**: 1-23.

Davis, J. J., 1926. Insects of Indiana for 1925. Proc. Ind. Academy Sci. **35**:310-319.

Drake, C. J. and Harris, H. M., 1934. The Gerrinae of the Western Hemisphere (Hemiptera). Ann. Carnegie Museum **23**:179-240.

Esaki, T., 1926. Ann. Mus. Nat. Hung. **23**:141.

Evans, J. Harwood, 1931. A preliminary revision of the ambush bugs of North America (Hemiptera, Phymatidae). Ann. Ent. Soc. America **24**:711-738.

Gould, George E., 1933. Some notes on the genus Rhagovelia with descriptions of a new species (Hemiptera, Celiidae). Ann. Ent. Soc. America **26**:465-471.

Knight, H. H., 1926. Notes on the species of Polymerus with descriptions of four new species and two new varieties (Hemiptera, Miridae). Canad. Ent. 58:164-168.

Knight, H. H., 1927. Notes on the distribution and host plants of some North American Miridae. Canad. Ent. 59:34-44.

Musgrave, L. I., 1934. Miridae heretofore unrecorded from Indiana (Hemiptera). Bull. Brook. Ent. Soc. 29:99-101.

AN ANNOTATED LIST OF THE BYTHOSCOPINAE OF INDIANA (CICADELLIDAE, HOMOPTERA)

DELMON W. LAHUE, Purdue University[1]

The subfamily Bythoscopinae is one of the five subfamilies of leafhoppers (Cicadellidae) occurring in Indiana. Thomas Say (1831)[2] recorded the first Bythoscopinae from Indiana when he described *Agalliopsis novella* and *Idiocerus verticis*. Since then, Van Duzee (1917) has recorded one additional species (*Aceratagallia sanguinolenta*), Breakey (1932) three additional species (*Macropsis viridis, M. erythrocephala, M. ferruginoidis*), and Oman (1932) another (*Agallia constricta*), making a total of seven species recorded from Indiana to date. The writer is adding 25 species in this paper, making a total of 32 species which are known to occur in the state.

Several species of Bythoscopinae are of economic importance. Alfalfa, Japanese and other clovers, beets and other truck crops, soybeans, and pasture grasses are the principal crops attacked. *Aceratagallia sanguinolenta*, *Agallia constricta*, and *Agalliopsis novella* are recognized as pests in Indiana. The species of *Macropsis*, *Oncopsis*, *Idiocerus*, and *Bythoscopus*, in general, feed on woody plants, but, because of the small numbers usually present, they do little damage.

In the following systematic treatment the species are arranged according to the classification of Van Duzee (1917) with systematic changes and additions to bring it up to date for the species known to occur in Indiana.

The initials of collectors of the specimens upon which this work is based are placed in parentheses after the collection record. These collectors and their initials are: D. W. Brinson (DWB), H. E. Brown (HEB), H. L. Cook (HLC), J. J. Davis (JJD), H. O. Deay (HOD), G. E. Gould (GEG), R. R. Heaton (RRH), B. E. Montgomery (BEM), L. I. Musgrave (LIM), F. H. Test (FHT), A. W. Tripple (AWT), Musgrave and Deay (M and D). Records on insects taken from the Purdue student collections are denoted by (PC) and the writers by (DWL). The county is taken as the collecting unit.

The writer wishes to express his appreciation to Mr. P. W. Oman, assistant Entomologist, U. S. National Museum, Washington, D. C., who checked the writer's identifications and made corrections when necessary, and to Dr. H. O. Deay, Purdue University, for his guidance in this study.

Species marked with an asterisk have not been reported from the state before.

Genus *Agalliopsis* Kirkaldy

1. *Agalliopsis novella* (Say, 1831).

Collection records: Carroll Co., July 28 (GEG); Harrison Co., May 13-Sept. 6 (DWL); Parke Co., June 26-28 (FHT); Porter Co., June 9 (HEB); Tippecanoe Co., May 9-July 11 (HOD, GEG, LIM, PC); Vigo Co., July 31 (HLC).

---

[1] Contribution from the Entomological Laboratories, Purdue University. The data used here were gathered by the writer during the preparation of his undergraduate thesis.

[2] Numbers in parenthesis refer to literature cited.

Notes: Taken on red beets, sweet clover, smart weed, and willow.

Thomas Say described this species from Indiana specimens as *Jassus novella* in 1831.

Genus *Agallia* Kirkaldy

2. **Agallia quadripunctata* (Provancher, 1872).

Collection records: Kosciusko Co., April 21-June 9 (GEG); Knox Co., May 30 (JJD); Lake Co., June 28 (GEG); Morgan Co., May 14 (PC); Parke Co., June 24 (FHT); Porter Co., June 9-21 (HEB); Rush Co., June 30 (RRH); Tippecanoe Co., April 14-Aug. 25 (GEG, RRH, LIM, AWT, PC); Warren Co., May 20 (GEG).

Notes: Taken on beets, horse radish, and lettuce.

3. *Agallia constricta* Van Duzee, 1894.

Collection records: Carroll Co., Aug. 31 (JJD); Harrison Co., May 15-Oct. 1 (DWL); Jefferson Co., July 15-Aug. 20 (DWB); Kosciusko Co., Aug. 11 (GEG); Lawrence Co., July 11-Aug. 16 (GEG, LIM); Morgan Co., May 14-July 23 (LIM); Parke Co., July 25 (FHT); Posey Co., Sept. 2 (HOD); Porter Co., July 8 (HEB); Rush Co., June 29 (RRH); Tippecanoe Co., April-Aug. 16 (HOD, GEG, LIM, AWT, PC); Vigo Co., July 31 (HLC); Warren Co., May 20 (HOD).

Notes: Taken on alfalfa, red beets, blue grass, red clover, locust, oak, potato, smartweed, and willow, and at "light trap."

Recorded as occurring in Indiana by Oman (1933).

Genus *Aceratagallia* Kirkaldy

4. **Aceratagallia accola* Oman, 1933.

Collection records: Harrison Co., Jan. 1-July 3 (DWL); Morgan Co., Nov. 7 (LIM); Noble Co., July 20 (HEB).

Notes: Taken on locust and meadow grass.

5. *Aceratagallia sanguinolenta* (Provancher, 1872).

Collection records: Bartholomew Co., Oct. 15, 1932 (GEG); Carroll Co., July 15 (GEG); Crawford Co., Aug. 30 (JJD); Harrison Co., Jan. 1-Sept. 16 (DWL); Jefferson Co., July 28-Aug. 20 (DWB); Johnson Co., Oct. 15 (HOD); Knox Co., June 23 (GEG); Kosciusko Co., June 22-July 20 (GEG); LaPorte Co., May 14 (JJD); Morgan Co., July 13-Nov. 7 (RRH, LIM); Noble Co., July 20 (HEB); Parke Co., July 12 (FHT); Porter Co., July 4-Aug. 12 (JJD); Rush Co., June 29-Sept. 28 (PC); St. Joseph Co., June 17-Sept. 7 (AWT, PC); Starke Co., May 22-Aug. 24 (PC); Tippecanoe Co., Jan. 13-Nov. 14 (HEB, HOD, RRH, LIM, PC, M and D); Warren Co., May 20 (HOD).

Notes: Taken on alfalfa, crabapple, red beets, blue grass, buckwheat, red clover, cottonwood, coxcomb, grape, mullein, potato, smartweed, tomato, and willow.

Recorded as occurring in Indiana by Van Duzee (1917).

6. **Aceratagallia vulgaris* Oman, 1933.

Collection records: Morgan Co., Nov. 7 (LIM); Tippecanoe Co., Nov. 6 (AWT).

Notes: Taken from mullein.

Genus *Idiocerus* Lewis

7. **Idiocerus nervatus* Van Duzee, 1894.

Collection records: Harrison Co., July 1-12 (DWL); Tippecanoe Co., Aug. 4-Sept. 25 (HOD, GEG).

Notes: Taken on willow and cedar.

8. **Idiocerus pallidus* Fitch, 1851.

Collection records: Harrison Co., July 1-12 (DWL); Morgan Co., July 9 (LIM); Rush Co., June 26 (RRH); Wabash Co., July 11 (GEG).

Notes: Taken on clover and willow and by sweeping grass.

9. **Idiocerus suturalis* Fitch, 1851.

Collection records: Porter Co., July (HEB); Tippecanoe Co., July 23-Oct. 8 (HOD).

Notes: Taken on willow.

10. **Idiocerus alternatus* Fitch, 1851.

Collection records: Harrison Co., June 27-Sept. 6 (DWL); Morgan Co., May 14 (PC); Rush Co., April 19-June 30 (RRH); Tippecanoe Co., April 19-Oct. 4 (GEG, LIM, PC).

Notes: Taken on locust and willow.

11. **Idiocerus moniliferae* Osborn and Ball, 1898.

Collection records: Harrison Co., Aug. 3 (DWL); Lawrence Co., Aug. 16 (BEM); Tippecanoe Co., Jan. 13-18 (HEB, GEG).

Notes: Taken on mulberry and willow and from under hickory bark.

12. **Idiocerus scurra* (Gemar, 1834).

Collection record: Tippecanoe Co., June (PC).

13. **Idiocerus formosus* Ball, 1902.

Collection record: Kosciusko Co., July 25 (GEG).

14. **Idiocerus lachrymalis* Fitch, 1851.

Collection records: Porter Co., June 2-July 8 (HEB).

Notes: Taken on blackberry and poplar.

15. **Idiocerus ramentosus* (Uhler, 1877).

Collection records: Clark Co., Aug. 31 (JJD); Harrison Co., June 20 (DWL); Kosciusko Co., May 14 (GEG); Morgan Co., May 14 (LIM); Tippecanoe Co., Apr. 19-Oct. 8 (HOD, RRH).

16. *Idiocerus verticis* (Say, 1931).

Collection records: Kosciusko Co., Aug. 10 (GEG); Morgan Co., Aug. 7-Oct. 14 (LIM, PC); Tippecanoe Co., May 3-Oct. 4 (GEG, LIM, PC).

17. **Idiocerus snowi* Gillette and Baker, 1895.

Collection records: Carroll Co., July 28 (GEG); Clay Co., June 21 (GEG); Tippecanoe Co., July 7-Sept. 30 (HOD, PC); Warren Co., June 27 (HOD).

18. **Idiocerus fitchi* Van Duzee, 1851.

Collection record: Harrison Co., June 10 (DWL).

Genus *Macropsis* Lewis

19. **Macropsis reversalis* (Osborn and Ball, 1898).

Collection records: Harrison Co., June 17-July 12 (DWL).

Notes: Taken from willow.

20. **Macropsis fumipennis* var. *gleditschiae* (Osborn and Ball, 1898).

Collection records: Adams Co., June 18 (GEG); Kosciusko Co., June 4 (GEG); Knox Co., May 30 (JJD); Morgan Co., June 10-12 (LIM); Tippecanoe Co., May 21-July 12 (GEG, LIM, M and D); Wells Co., June 18 (GEG).

Notes: Taken on honey locust.

21. **Macropsis virescens* (Gmelin, 1788).

Collection record: Morgan Co., June 10 (LIM).

22. *Macropsis viridis* (Fitch, 1851).

Collection records: Carroll Co., June 28 (HOD); Harrison Co., June 24-July 12 (DWL); Jefferson Co., June 5-23 (DWB); Morgan Co., May 28 (LIM); Noble Co., June 21 (HEB); Rush Co., June 20-30 (RRH); Tippecanoe Co., June 1-July 23 (HOD, M and D, AWT); Wells Co., June 18 (GEG).

Notes: Taken on willow and at "light trap."

23. *Macropsis erythrocephala* (Gillette and Baker, 1895).

Collection records: Harrison Co., June 20-27 (DWL); St. Joseph Co., July 11-22 (AWT); Tippecanoe Co., June 1-July 20 (GEG, BEM, AWT, M and D).

Notes: Taken on willow and at "light trap."

24. **Macropsis bicolor* (Osborn, 1915).

Collection records: Orange Co., May 26 (PC).

25. *Macropsis ferruginoides* (Van Duzee, 1889).

Reported from Indiana by Breakey (1932).

26. **Macropsis trimaculata* (Fitch, 1851).

Collection records: Allen Co., June 17 (JJD).

Notes: Taken on grape.

27. **Macropsis osborni* Breakey, 1932.

Collection records: Tippecanoe Co., June 2 (LIM).

Notes: Taken on willow.

28. **Macropsis insignis* (Van Duzee, 1889).

Collection records: Noble Co., July 20 (HEB).

Notes: Taken on cottonwood.

Genus *Oncopsis* Burmeister

29. **Oncopsis distinctus* (Van Duzee, 1890).

Collection records: Harrison Co., Sept. 6 (DWL); Noble Co., Sept. 4 (HEB); Rush Co., June 8-18 (RRH); St. Joseph Co., June 17 (PC); Tippecanoe Co., June 26-Oct. 1 (HOD, GEG).

Notes: Taken on willow, walnut, and mint.

30. **Oncopsis nigrinasi* (Fitch, 1831).

Collection records: Parke Co., July 29 (GEG).

Genus *Bythoscopus* Germar

31. **Bythoscopus apicalis* (Osborn and Ball, 1898).

Collection records: Carroll Co., July 15 (GEG); Harrison Co., June 16 (DWL); Knox Co., June 23 (GEG); Tippecanoe Co., July 4 (GEG).

32. **Bythoscopus alabamensis* (Baker, 1900).

Collection records: Harrison Co., Sept. 7 (DWL); Knox Co., June 23 (GEG); Tippecanoe Co., June 12-Oct. 4 (LIM, M and D).

Notes: Taken on alfalfa and willow.

Literature Cited

Breakey, E. P., 1932. A review of the nearctic species of Macropsis. Ann. Ent. Soc. Amer. **30**:786-844.

Oman, P. W., 1933. A classification of North American agallian leafhoppers. U. S. D. A. Tech. Bul. 373.

Say, T., 1831. Descriptions of new North American hemipterous insects belonging to the first family of the section Homoptera of Latreille. Jour. Acad. Nat. Sci. Phila. **6**:235-244; 299-314.

Van Duzee, E. P., 1917. Catalogue of the Hemiptera of America north of Mexico, excepting Aphididae, Coccidae, and Aleurodidae. Univ. of Calif. Pub., Div. of Ent., Tech. Bul. **2**:569-590.

THE HABITS AND EARLY STAGES OF THE DRAGONFLY, *GOMPHAESCHNA FURCILLATA* (SAY)

Clarence Hamilton Kennedy, Ohio State University

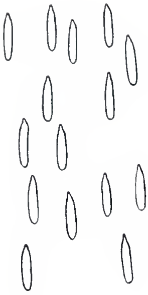
In the year 1917, while at Cornell University, the writer made a few observations on the habits and first three instars of the dragonfly, *Gomphaeschna furcillata* (Say). With the rearing of the third instar, study was interrupted, and no further opportunity has occurred for its continuation. This species appears to be limited to sphagnum bogs and is recorded from Maine south to Georgia and west to Ohio. A second species, *G. antilope* Hagen, the habits of which are unknown, is recorded from New Jersey, Maryland, Pennsylvania, and Virginia. The two species have venational characters which suggest relationship to the related family Gomphidae; hence the question has been raised as to whether the nymph might show gomphine characters. We present the following notes because of this possible relationship and also the fact that Gomphaeschna, considered one of the primitive genera in this family, is almost the last genus of large dragonflies north of Mexico whose nymphal stages are undescribed.

Gomphaeschna was discovered about the small sphagnum bog at Ringwood, on the highland, seven miles east of Ithaca, New York. One specimen was taken one mile and a half farther east on Bear Creek. In the latter part of May or early June, 1917 (exact records lost), fifteen to twenty individuals were captured while they were flying up and down the road that passes the Ringwood bog. Fully as many others escaped. Those taken were mostly males which, though not teneral, were not fully mature. Though at that time the neighboring ponds and streams were closely inspected for emerging individuals, the bog was unsuspected.

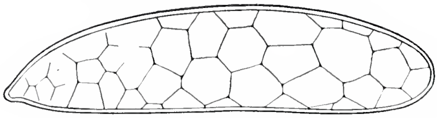
On June 27, 1917, after observing a half dozen or so individuals, a female Gomphaeschna was followed from the road into the sphagnum bog to the east. She settled and oviposited in the soft, rotten part of the root of a small tree in the middle of the sphagnum area. As the part chosen was six inches above the shallow water, she was easily observed. Over an area three inches long and two inches wide she tried various spots with the tip of her abdomen and eventually inserted her ovipositor more than thirty times. Except that the tips of the eggs were visible and all had their sharp points up, they showed no particular arrangement. (See Figures 1 and 2.) Thus her actions in oviposition were those of Aeschnid females in general. After oviposition, the female was captured and taken to the laboratory.

On July 7, when the third trip was made to Ringwood, only three males were seen. None were found during a fourth trip made on July 14. From these data it appears that the height of abundance on the wing was past on June 27. This relatively early flight season for dragonflies on the highlands east of Ithaca suggests primitiveness (Kennedy, 1928).

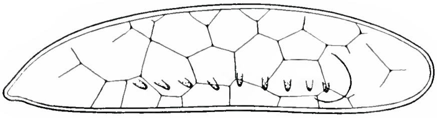
At the laboratory, the wood containing the clutch of eggs was partially submerged in a shallow dish of water. The first nymph was found July 23, 1917, twenty-seven days after oviposition. By July 30 practically all the eggs appeared to have hatched; my records, however, state that one more hatched between August 4 and August 6.



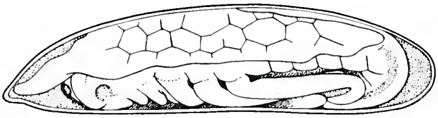
1



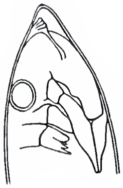
3



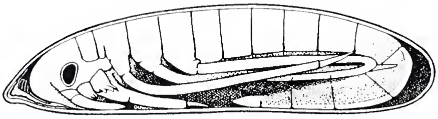
4



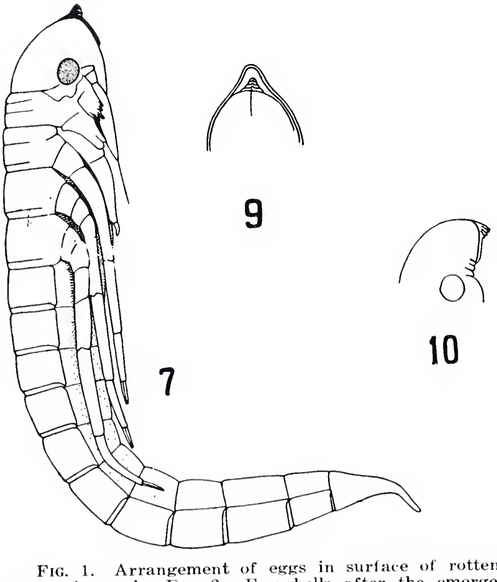
5



8



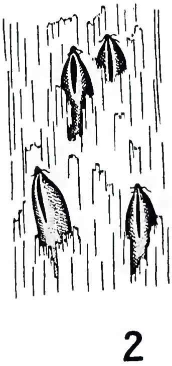
6



7

9

10



2

FIG. 1. Arrangement of eggs in surface of rotten tree root. The pointed end is the anterior end. FIG. 2. Egg-shells after the emergence of the pronymphs. FIG. 3. Egg seven days after oviposition showing the reticulation of the surface (?) of the contents. FIG. 4. Egg twelve days after oviposition showing nine pairs of appendages and reticulation clearing up at poles of egg. FIG. 5. Egg nineteen days after oviposition. Appendages well developed; reticulation reduced to dorsal area. FIG. 6. Egg twenty-six days after oviposition. Pronymph developed except for some joints in the appendages. FIG. 7. Pronymph free from the egg-shell. FIGS. 8-10. Views of the egg-burster.

The Speed of Development. By the scattering of the hatching dates, the speed of development was not the same in all the eggs of this (probably) single clutch. (There is a possibility, of course, that other females had oviposited previously in the same wood.) This difference in developmental speed was shown also in the development of the young nymphs. Sixteen nymphs (Nos. 401-416) were segregated into as many vials. The remainder were continued in a porcelain dish. All were fed Paramecia. On August 20, when all the material still living was preserved, less than half of those in the porcelain dish were in the second instar. The records for the sixteen nymphs segregated July 25 and reared individually follow: on the first careful examination, August 2, one had died in Instar I; six had passed into Instar II. On the second examination, August 13, seven more had passed into Instar II. By August 16, the two remaining had reached Instar II. These records indicate that the length of Instar I was from 10 to 19 days.

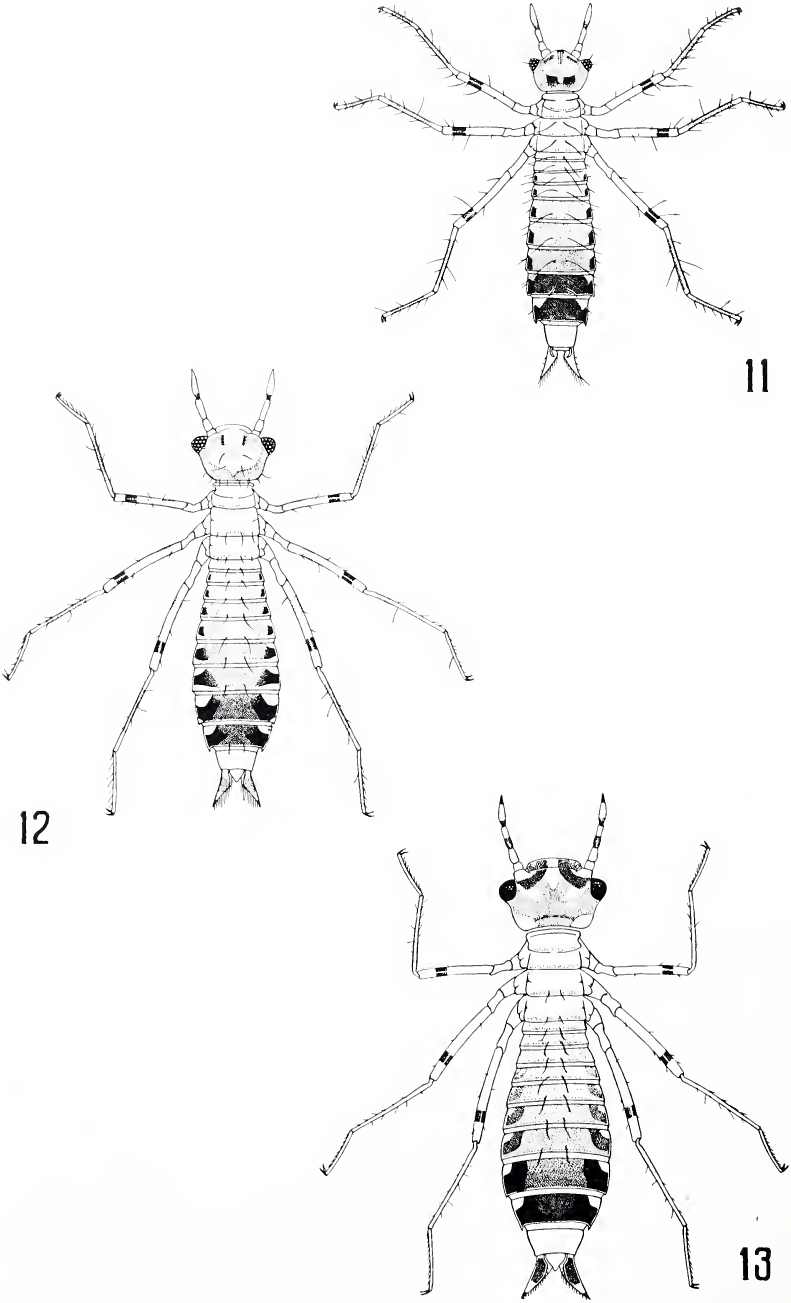
Only one nymph (No. 403) passed into Instar III. This was segregated July 25, passed into Instar II, August 2, and into Instar III, August 12-13. It died in Instar III, August 19-20. With this nymph the length of Instar II was 10-11 days. An examination of its labium showed that at death it was not yet in the preliminary stages of moult. (Figure 28 shows this preliminary stage in another nymph.)

Embryological Notes. Camera lucida drawings from live material of four stages in the development of the embryo are shown in Figures 3-6. On July 3, seven days after oviposition (Fig. 3), the only feature visible was the reticulation of some subchorion membrane. The reticulations appeared to be "cellular" areas. On July 8, twelve days after oviposition (Fig. 4), nine appendages were visible on the ventral surface. This stage appeared to follow the revolution of the embryo, because the four oblique appendages, which were probably antennae and mouthparts, were at the anterior pole of the egg. The general reticulation was breaking up at the poles of the egg. On July 15, nineteen days after oviposition (Fig. 5), the head, body and appendages were taking on pronymphal form, except for the dorsal region where there was yet a remnant of the reticulated area. (Notice the partially developed egg-burster which appears in this stage as a growth on the *inner* surface of the pronymphal envelope.) On July 22, twenty-six days after oviposition (Fig. 6), the pronymph was fully formed, except that not all the segments of the appendages were yet distinct.

Figure 2 shows some of the empty, ragged-tipped eggshells, which are brown after the emergence of the nymph. The raggedness was not noticed in the freshly laid eggs.

The Egg-burster and Hatching. Hatching takes place through a slit in the chorion (Fig. 2), probably produced by movements of the pronymph, and aided by the sharp, sclerotized egg-burster. The use made of the egg-burster is indicated by the forward-bending motions of the head which are continued for some moments after release from the egg-shell (Fig. 10).

The pronymph is the last embryonic and the first free stage. In Gomphaeschna, it wriggles free from the egg-shell and struggles to the



Figs. 11-13. Instars I, II, and III, respectively.

substratum by flopping movements of the abdomen and remains bent in an L-shape. The legs and other appendages remain rigid. In a very few minutes, or sometimes almost as soon as freedom from the egg is accomplished, the pronymphal skin rips along the mid-dorsal line, and the first instar nymph pulls itself out, extends its legs, and assumes a very cocky pose. (In Anax, another Aeschnid, the pronymphal skin remains in the egg-shell, the first instar nymph being the first free stage.)

Pronymph. (Figures 7-10.) Because few pronymphs have been described and group characters are unknown, we shall not attempt a detailed technical description. In Gomphaeschna it is 3.75 mm. long, which is 1.75 mm. longer than the egg, and nearly 2 mm. longer (frons to tip of candal appendages) than Instar I. Except for the dark eyes and the sclerotized tips of the mouth-parts it is without color.

Balfour-Brown (1909) figures the pronymph of *Ischnura elegans* Lind., which is Zygopterous. In Gomphaeschna the conical terminal segment is twice the length of abdominal segment 10; in Ischnura it is four and one-half times as long as segment 10. In Gomphaeschna the eye is twice the width of antennal segment 1; in Ischnura it equals that segment. In Gomphaeschna, the egg-burster is well developed. In Ischnura, little or no egg-burster occurs, while the nymph ruptures the chorion through a swelling of its head which appears to drive some fluid ahead of it into the anterior end of the egg-shell. From the preceding there appear to be some subordinal differences between the pronymph of Ischnura (Zygopterous) and that of Gomphaeschna (Anisopterous).

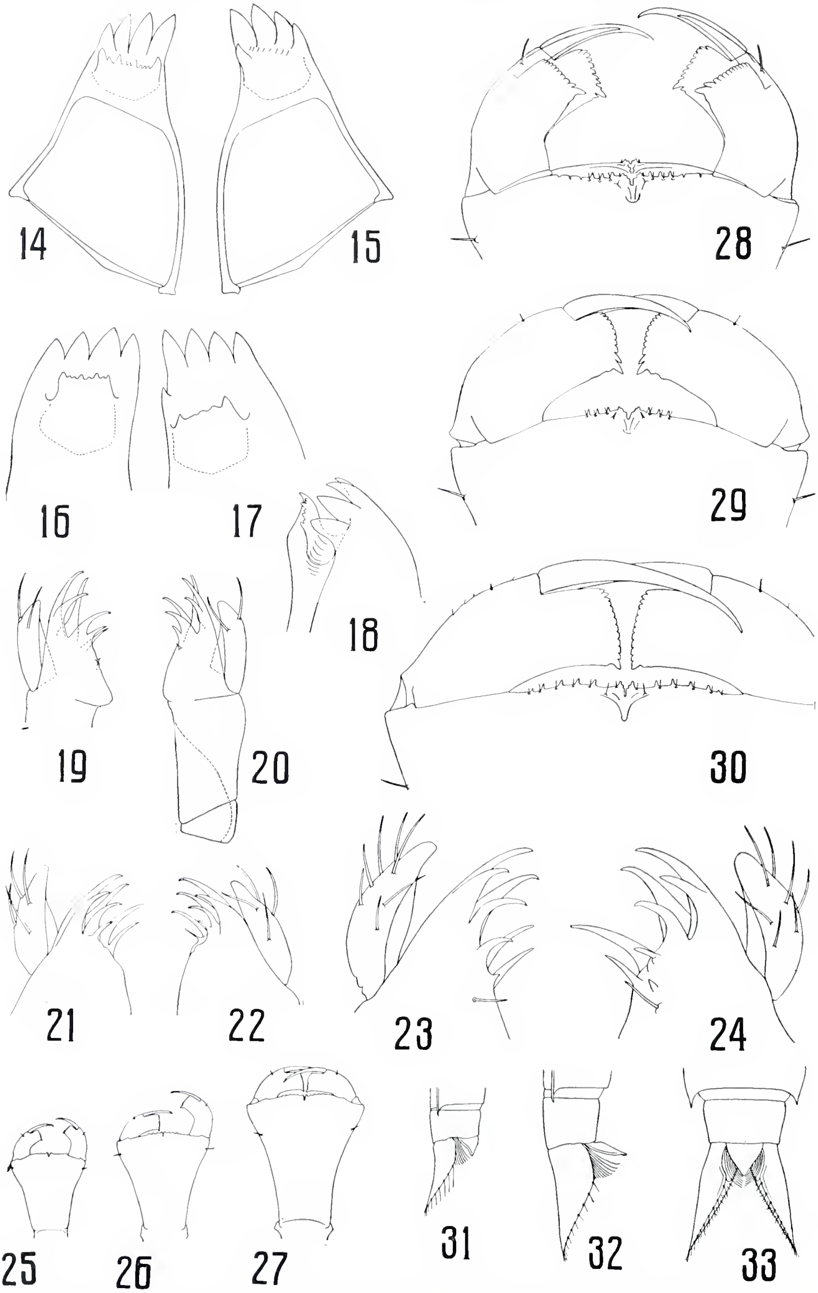
In Gomphaeschna, legs 2 and 3 (Fig. 7) show what appear to be subcoxal segments. This puzzled me when the figure was drawn in 1917 as I had not heard of subcoxal segments. To determine whether they are true segments or not will require further study.

Balfour-Brown's Figure 4 is wrong in that the right fore leg is shown extending to the apex of abdominal segment 6, while its mate extends to segment 8, where its tip turns forward. In this illustration, the distal part of the left fore leg is probably leg 3 improperly drawn on the base of the former. Such a mistake could have happened very easily under a high magnification of a whole mount.

Instar I. (Figures 11, 14, 15, 19, 20, 25, 28 and 31.) Length 1.75-2.00 mm., when fully extended a half-hour after ecdysis of the pronymphal skin. Aeschnid in general form characterized by long hairs (Fig. 11). Color pattern distinguished by pairs of spots on abdominal segments 3 to 9, with segments 8 and 9 very dark. Legs with conspicuous subapical ring. No wing pads. Tarsi one-segmented.

Head with frons arched forward more than in later instars, from eye to eye 120° of a circle. Compound eyes with two bristles each and tending to a conical shape. "Posterior angles" of head rounded; occiput square across. Antennae three-segmented; segments 1 and 2 subequal in length, segment 3 almost three times the combined length of 1 and 2, constricted at midlength.

Mandibles (Fig. 14, left and 15, right) with four long incisor teeth each. The left with a poorly developed row of minute teeth on the inner base of incisor row. (This inner row in later instars develops into the



FIGS. 14 and 15. Inner views of left (14) and right (15) mandibles of Instar I. FIGS. 16 and 17. Inner views of left (16) and right (17) mandibles of Instar III. FIG. 18. Ventral view of apex of left mandible of Instar III, showing molar teeth and fossa. FIGS. 19 and 20. Ventral views of right (19) and left (20) maxillae of Instar I. FIGS. 21 and 22. Ventral views of right (21) and left (22) maxillae of Instar II. FIGS. 23 and 24. Ventral views of right (23) and left (24) maxillae of Instar III. FIGS. 25-27. Views of dorsal or inner surfaces of the labia of Instars I (25), II (26), and III (27). FIGS. 28-30. Views of dorsal or inner surfaces of labia of Instars I (28), II (29), and III (30). Figure 28 is of a larva in the initial stages of ecdysis from Instar I into Instar II. The labial teeth of both instars are visible. FIG. 31. Lateral view of abdominal segment 10 and appendages of Instar I showing the epiproct, the left paraproct, and hairs of the respiratory valve. FIG. 32. Lateral view of abdominal segment 10 and its appendages in Instar III. FIG. 33. Dorsal view of same parts of Instar III as shown in figure 32.

molar prominence and in the exuvium is usually split from the incisor row as its base is on a membraneous area.) Right mandible (Fig. 15) with no molar row of teeth but with a short incisor tooth at base of the lowest or ventral incisor.

Maxillae (Fig. 19, right, 20, left) with an inner and an outer row of three teeth each. Two hairs on the palp.

Labium Aeschnid; when folded extending to between middle coxae (Fig. 28). Each lateral lobe with eight terminal teeth plus the larger single tooth at its inner angle. Anterior edge of mentum with two teeth at its middle between which a minute notch.

Abdomen 3¼ times as long as wide; widest at segments 7 and 8. Posterior "angles" of segment 8 angular but without hooks, of segment 9 with hooks as long as the intersegmental membrane. Segment 10 one-half as wide as segment 8.

Anal appendages three, a short, triangular epiproct (*appendix dorsalis*) one-half to three-fifths as long as segment 10, and two three-cornered, acutely pointed paraprocts twice as long as segment 10. No cerci.

In the use of terms for the abdominal appendages Snodgrass, (1935) has been followed. The epiproct is called the *appendix dorsalis* by Tillyard (1917). The paired appendages which we have termed paraprocts, following Snodgrass, are called *cerci* by Lucas (1930) and by Calvert (1934) who follow Heymons (1904). The upper pair of caudal appendages, which in Gomphaeschna have not appeared yet in Instars I-III, are termed *cercoids* by Heymons and *cerci* by Snodgrass. We have not been able to distinguish the sexes in Instars I and II by any difference in the epiproct as is shown in later instars.

Instar II. (Figures 12, 21, 22, 26 and 29.) Length 2.5 mm. General form as in Instar I but with head more angular. No wing-pads or cerci. Tarsi one-segmented. Differing from Instar I in having antennae four-segmented, the constriction in the terminal segment of Instar I having been completed. Color pattern (from preserved material) similar to that of Instar I, except for changes in head color and a faint band about each paraproct. Hairs not proportionally as long, hence less conspicuous than in Instar I.

Left mandible as in Instar I. Right mandible with its first well-developed molar teeth, at the outer end of which row, the odd or fifth incisor tooth.

Maxillae (Figs. 21 and 22) as in Instar I, except for four hairs on the palp. Labium (Figs. 26 and 29) as in Instar I, but with 10-11 terminal teeth on lateral lobe and three extra teeth on each side of original middle pair on anterior edge of mentum. Each of the eight mental teeth with a minute bristle at its outer side. Abdominal structures as in Instar I.

Instar III. (Figures 13, 16-18, 23, 24, 27, 30, 32 and 33.) The single individual, No. 403, reaching this stage, 3 mm. long. Except for greater size, general form similar to that of Instars I and II. Antennae four-segmented, tarsi one-segmented, no wing pads or cerci. Color in general as in earlier stages, except antennae with tips black, a band on base of apical and subapical segments. Two distinct spots developed between the eyes on dorsal surface of head. Bands on middle of paraprocts distinct. (Color sketched from live nymph in 1917.)

Mandibles, as in previous instars, but molar row of teeth better developed and more remote from incisor row; that on the right mandible being twice as far below incisors as that on the left. Each molar row with a fossa (Fig. 18) developed between it and the incisors. (Figure 18 is a fore-shortened end-view of the fossa.)

Maxillae (Figs. 23 and 24) with four teeth in each row and at least seven hairs on the palp. (Figure 24 shows one tooth in the outer row damaged and replaced by a peg.)

Labium (Figs. 27 and 30) differing from that in previous instars in having on each lateral lobe 12 apical teeth plus the large tooth on the inner angle; anterior edge of mentum with five teeth on each (?) side of middle pair of teeth. (In this individual five on left and four on right side.) Caudal appendages (Figs. 32 and 33) as in Instars I and II.

General Considerations. From the characters of the first three instars the nymph is wholly Aeschnid in the strict sense. It has no Gomphid characters in antennae or in labium. We can only speculate on the generic characters of a fully grown nymph. The present data suggest that the occipital "angles" of the head may be rounded and that segment 9 has spines while segment 8 is without. Probably cerci and a spine on the epiproct develop in later stages. The color pattern suggests the spotted pattern of the nymph of *Nasiaeschna pentacantha* (Rambur) which rates as a primitive Aeschnid.

Literature Cited

Balfour-Brown, Frank, 1909. The life history of the Agrionid dragonfly. Proc. Zool. Soc. Lond. **1909**:253-285, pls. 33 and 34.

Calvert, P. P., 1934. The rates of growth, larval development and seasonal distribution of dragonflies of the genus Anax (Odonata: Aeshnidae). Proc. Amer. Phil. Soc. **73**:1-70, pls. I-IV.

Handlirsch, Anton, 1903. Zur Morphologie des Hinterleibes der Odonaten. Ann. k. k. Naturhist. Hofmus. Wien **18**:117-122, figs. 1-13.

Handlirsch, Anton, 1904. Bermerkungen zu der Libellen. Ann. k. k. Naturhist. Hofmus. Wien **19**:59-63.

Heymons, R., 1904. Die Hinterleibsanhänge der Libellen und ihrer Larven. Ann. k. k. Naturhist. Hofmus. Wien **19**:21-58, pl. I.

Kennedy, C. H., 1928. Evolutionary level in relation to geographic, seasonal and diurnal distribution of insects. Ecology **9**:357-379, 5 charts.

Lucas, J. L., 1930. The aquatic (naiad) stage of the British dragonflies (Paraneuroptera) Ray Soc. Vol. 117, pls. I-XXXV, text figs. 1-30.

Snodgrass, R. E., 1935. Principles of insect morphology. McGraw-Hill Book Company. New York.

Tillyard, 1917. The biology of dragonflies. Cambridge Univ. Press.

HERPETOLOGICAL NOTES FROM NORTHERN INDIANA

Chapman, Grant, San Diego, California

The following notes were taken from January 20 to July 12, 1934, while the writer was on duty as the C. C. C. District Commander for the northern half of Indiana. Most of these observations were made in the Jasper-Pulaski (Counties) State Game Preserve, in the Indiana Dunes State Park (Porter County), and in the southwest corner of Starke County. These localities will be abbreviated hereunder by "J-P", "Dunes", and "Starke" respectively. Mr. H. B. Seward, of the Indiana Department of Conservation, made the appended herpetological observations within the Jasper-Pulaski State Game Preserve between June 21 and Dec. 20, 1933. Pertinent quotations are also appended from the Annual Reports of the Department of Conservation of the State of Indiana for 1931, 1932, and 1933.

Evermann and Clark have covered the area of Lake Maxinkuckee, Schmidt and Necker have treated the Chicago and Dunes areas, and Hay, Blatchley, and a few others have made observations within the area covered by the present notes. The collection was presented to Mr. L. M. Klauber of San Diego, California.

Amphibia

Ambystoma jeffersonianum (Green). Jefferson's Salamander.

Four specimens were taken on April 8 while digging for the abutment of a bridge at the Dunes. One specimen was found on April 30 at J-P under a log, the first specimen of any kind taken under countless logs which I have turned in this park. One specimen was found under a log on May 4, two miles west of Woodville, Porter County. Evermann and Clark found only five specimens at Lake Maxinkuckee, while Schmidt reports it common near Chicago.

Ambystoma maculatum (Shaw). Spotted Salamander.

One specimen was taken on May 6 five miles west of Valparaiso under a log in damp ground. The spots behind eye and "ear" were bright orange, the remaining spots clear yellow. Evermann and Clark mention only two specimens, while Schmidt reports it as locally abundant near Chicago.

Plethodon cinereus (Green). Red-backed Salamander.

Thirty-five specimens were collected on April 21 at Sager's Pond, Valparaiso, under small logs on top of moist dead leaves. They were more numerous on the ridges than near the bottoms. All were torpid and none were present under logs where field mice lived, nor where the leaves were dry. Eight had red backs and twenty-seven had gray backs. On April 26 seventeen more were taken at the same place. Four had red backs and thirteen had gray backs. On April 28 three were taken three miles southwest of Valparaiso, two having red and one gray backs. On May 6 nine were taken five miles west of Valparaiso, six with red and three with gray backs. In the Valparaiso area approximately thirty percent have red backs and seventy percent gray backs.

Siren lacertina Linnaeus. Siren.

One specimen was taken on April 11 in a drainage ditch at J-P by Mr. H. B. Seward and later liberated. I did not see the specimen. This species was not taken by Evermann and Clark at Lake Maxinkuckee nor by Schmidt in the Chicago area. Blatchley does not mention it from the lakes of northern Indiana. Hay lists it from Lafayette, about fifty miles south of J-P. Schmidt and Necker report it from Hebron, Porter County.

The above notes are in agreement with Evermann and Clark that the Caudata are poorly represented in the Maxinkuckee-J-P area and with Schmidt that they are more numerous farther north.

Bufo americanus Holbrook. Common Toad.

One specimen was collected at a small pond three miles west of Valparaiso on May 20. Very few specimens were seen and no notes taken.

Bufo fowleri Hinckley. Fowler's Toad.

One specimen was taken at the Dunes on May 29. No others were seen. This species is not mentioned by Evermann and Clark, which is in agreement with its not being found at J-P.

Acris crepitans Baird. Cricket Frog.

One was taken on April 2 five miles southeast of Chesterton.

Hyla crucifer Maximilian. Spring Peeper.

They were singing in chorus early in April five miles southeast of Chesterton.

Rana cantabrigensis (Baird). Wood Frog.

One male was found at the Dunes on April 2, and on the 8th. eight mating specimens were collected. All colors and variants described by Hay were present in this group. One of the above females laid about 700 eggs on April 10.

Rana catesbeiana Shaw. Bull Frog.

A large female, 15 cm. snout to vent, allowed herself to be picked up at Flint Lake, Valparaiso on May 5. She was full of eggs. Ordinarily they are very wild there. Six large specimens were shot by boys at Mink Lake, three miles north of Valparaiso on May 22.

Rana pipiens Schreber. Leopard Frog.

These were numerous on April 2 just south of Chesterton. One male was taken one mile south of Wanatah, Starke County, on April 7. A few were seen on May 9 at the duck pond at J-P.

Reptilia

It seems strange that Evermann and Clark made no mention of lizards in their work on Lake Maxinkuckee. Myers, quoting Hay, confines all lizards except the glass snake to the southern half of the state but later corrects the statement when he finds that Blatchley recorded the swift as being common in the Dunes in 1897. Schmidt and Necker list three species in the Chicago area.

Ophisaurus ventralis (Linnaeus). Glass Snake.

A male was found April 7 crawling on the surface at J-P. This lizard gives off a very disagreeable odor. Additional records are as follows: Dunes, one specimen, May 3; Starke, a male, May 16; J-P, a female, May 17; Dunes, a male, May 22, body 18.2 cm., tail 41 cm. When handled, this lizard feels as if it were creaking and preparing to shatter. Myers gives the range as "occasional throughout the State". Since it is not reported from Ohio or Michigan, it would seem that a more accurate definition of the range would prove interesting.

Cnemidophorus sexlineatus (Linnaeus). Six-lined Swift.

A pair, the male more brightly colored than the female, was dug up at Starke on April 20, where a foundation was being excavated. The day was cold with snow flurries. Both specimens were torpid and very fat. The following specimens were also taken: J-P, a female on May 8 and another specimen on May 17; Starke, a male on May 21 and nine more from June 5 to 10; a female at the Dunes on May 23.

Sceloporous undulatus (Latreille). Fence Lizard.

Two specimens were taken at the Dunes on June 5. These specimens may have been brought from Fort Knox, Kentucky, by the C. C. C. boys and liberated in the park. Hay records a specimen from near Indianapolis.

Eumeces fasciatus (Linnaeus). Blue-tailed Skink.

One specimen was taken under bark at J-P on April 25. Another specimen was taken at Valparaiso under bark on April 28.

Phrynosoma sp. Horned-toad.

On May 29 at Valparaiso a small boy brought me a bottle of water containing a bloated and nearly drowned horned toad. It had been mistaken as a dangerous animal and injured in capture. When released on the carpet it soon dried off and was borne off in triumph by an enlightened herpetological enthusiast. It was clearly an escaped individual.

Heterodon contortrix (Linnaeus). Hog-nosed Snake.

Two specimens were found at J-P on April 18, and one spotted specimen on May 25. One gray specimen was taken in Starke on May 24.

Eurypholis vernalis (Harlan). Green Snake.

Two specimens were collected by Mr. Seward at J-P on May 21. See also Appendix.

Coluber constrictor flaviventris (Say). Blue Racer.

Four specimens were taken at J-P on April 18. Many more were seen this date crawling through a field, apparently just emerged from hibernation and seemingly moving in one general direction. On April 24 one specimen was taken at the Dunes. Description: 108 to vent, tail 35.5 cm.; belly clear bluish white, sides blue, back olive green. On May 7, five miles north of J-P a specimen was seen on the road with head held high. It hurried off when the car was sighted. On the same day a male was taken at the Dunes. Description: 75 to vent, tail 27 cm.; belly light blue, sides beautiful sky blue, back blue-green, throat and lips white, snout olive brown, lores black. Another Dunes specimen taken May 12, a male, had an abscess or growth on the right jaw. Description: body 67, tail 28 cm. Another J-P specimen scurried off the road on May 17. Two specimens were taken at Starke on May 21 and a young specimen on the 24th. One of the Dunes foresters states he saw "a ball as large as a bushel basket of blue racers scooped out of a sand bank by a steam shovel last winter."

Elaphe vulpina (Baird and Girard). Fox Snake.

Two specimens were taken at J-P on May 21. A car-killed specimen was seen on the road five miles north of J-P on June 28. The C. C. C. boys have captured and sold about a dozen specimens to date.

Lampropeltis t. triangulum (Lacepede). Milk Snake.

Three car-killed specimens were seen on the road between Valparaiso and J-P on May 21, and two live specimens were taken at J-P the same day. No others were seen the whole season. It appears that various species of snakes emerge from hibernation under specific climatic conditions, crawl to their feeding grounds, and are seldom seen again until time for the hibernating movement.

Natrix septemvittata (Say). Queen Snake.

One small specimen was taken at Sager's pond, Valparaiso on April 17. The specimen seemed to be diseased, having swellings on body and lower jaw. Another specimen was seen at the same time. It is known locally as "bull snake". The tail is prehensile.

Natrix s. sipedon (Linnaeus). Water Pilot.

One specimen was seen two miles west of Woodville, Porter County, on May 4. Three specimens were seen at Flint Lake, Valparaiso on May 6. A specimen was taken west of Woodville on May 8, and another on May 14. Description of the latter: body 44, tail 13.9 cm. A juvenile taken at the Dunes, May 18, had body 23.1, tail 7.3 cm. A male was taken at Mink Lake, three miles north of Valparaiso on May 22. One specimen was taken at the Dunes on June 30.

Storeria dekayi (Holbrook). Brown Snake.

The following specimens were taken; a male, J-P, April 11; a female, Dunes, April 12; a female found lying on the ground near a drainage ditch in the sun on April 18; a male, Starke, April 23; two females, J-P, April 30; a pair, Dunes, May 1; a male, Dunes, May 3; a specimen under a log two miles west of Woodville, Porter County, May 4; a female, Dunes, May 18.

Thamnophis butleri (Cope). Garter Snake.

A male was taken on the road five miles north of Valparaiso. Evermann and Clark record one specimen.

Thamnophis s. sauritus (Linnaeus). Ribbon Snake.

A male was found crawling at J-P on March 20.

Thamnophis s. sirtalis (Linnaeus). Garter Snake.

One specimen was taken on January 20 two miles north of Tefft, Porter County, coiled on the grass beside a drainage ditch. I rejoiced at finding what appeared to be the first specimen of a collecting season. The truth appears to be that a January specimen is a late record and that the season does not begin until the latter part of March. A male was found crawling at J-P on March 20, and several specimens had been dug from hibernation prior to this date. The following specimens were also taken; five males, Dunes, April 2; a pair, J-P, April 6; and a very fat female containing a frog April 11; a male, Dunes, April 12; one car-injured specimen, two miles north of Reynolds, White County, April 15; a female, Dunes, April 19; a male, Valparaiso, May 4; one specimen, Dunes, May 12; one seen three miles west of Valparaiso, May 20.

Sistrurus c. catenatus (Rafinesque). Rattle Snake.

Two specimens were taken in wet ground near the Boy Scout Camp at the Dunes on May 3.

Sternotherus odoratus (Latreille). Musk Turtle.

One specimen was taken at J-P on May 21, and another on the Kankakee River, opposite Riverside, on May 26. It was a male with tectiform carapace. It was not vicious but would bite at an eraser lightly when teased. The University of Valparaiso collection contains one specimen, a female, labeled Flint Lake.

Kinosternon subrubrum (Lacepede). Mud Turtle.

This species was not recorded from Lake Maxinkuckee by Evermann and Clark nor by Schmidt and Necker from the Chicago area. It was reported by Blatchley in 1900 thirty miles east of Maxinkuckee. Hay records it from Knox and Vigo counties on the western edge of the state. Blatchley found it common at Bass Lake fifteen miles west of Lake Maxinkuckee. It is not reported from Michigan by Gaige nor from Ohio by Conant. It, therefore, seems confined to the western edge of the state, possibly in communities, and not "probably throughout the state" as Myers states.

The first specimen was taken in a drainage ditch at J-P on April 13, a female on the 18th., and two more on the 30th. A female was taken at Starke on the 23rd. and a male and three females on May 7. A pair was found mating, walking on the bottom of a shallow pond at J-P, on May 9. When picked up they separated. Two more females and another male were taken at the same time and place. A pair, mating, and another male were taken at Starke, May 11. Five males and three females were taken at Starke, May 15. Two were taken in a practically dried up swamp at J-P on May 17.

This species tames easily, is docile, refuses to bite, feeds readily, and was not known to give off any odor. There are evidences of shells being gnawed by rodents.

An article by the present writer on the sexual dimorphism of this species has appeared in the American Midland Naturalist.

Chelydra serpentina (Linnaeus). Snapping Turtle.

A male was taken at J-P on April 11. A large vicious female taken at Valparaiso, April 30, had a carapace 18x24 cm. Another large female was taken at J-P May 7. Three large specimens in the laboratory of the University of Valparaiso were examined May 17. They had been taken by flashlight while apparently feeding on the banks of the stream emptying into Sager's pond. Three juveniles from a creek west of Chesterton were taken on May 18. They had apparently just hatched but no egg tooth was present. They measured 26x26, 30x30, and 32x32 mm., respectively. The underside of marginals and spots on the plastron were blue-white. One specimen was taken at Starke May 21. Many more specimens were seen than are shown in the above notes.

Clemmys guttata (Schneider). Spotted Turtle.

Twelve specimens from J-P were taken from shallow drainage ditches on April 18. They are very gentle and allow their legs and tail to be extended without evidence of fear.

Ten specimens were taken from drainage ditches at Starke on April 18, and six more on April 23. A pair was seen at J-P on April 30 trying to mate on moist ground. Both specimens were old with smooth scutes, the male much the smaller. A shell was found which had been gnawed into by some rodent. Another pair were observed mating at J-P on May 1, and several pairs in captivity were mating. The males pay no attention to other males or to *Kinosternon* which are in the same inclosure. A male was observed to be kicking or stroking his tail with his hind feet alternately or with both together. A specimen was taken in a flowing creek five miles west of Valparaiso on May 6. This is the only specimen seen in other than still water. A female was taken on May 6 at Flint Lake, Valparaiso. A pair of old specimens with badly mutilated shells were taken at Starke on May 7. The shells of two young were found where some animal had killed them, consuming the heads and fore feet and leaving the shell on the bank. A juvenile was found dry on a tuft of grass where some animal had tried to devour the fore legs; they were partly skinned, and the head was paralyzed. This specimen measured 47x52 mm., and another slightly smaller specimen was found alive, together with six adult females and three males, at J-P on May 9. A female was taken at Starke on May 11. Several specimens were seen along the edge of a deep drainage ditch on the south edge of Porter County on May 17. The other species were in the center of the ditch. Two specimens from the southwest corner of Starke County were taken on May 21. A female was found dead, its head and fore feet eaten off, in J-P on May 21.

An article by the present writer on the sexual dimorphism of this species appeared in the last issue of the Proceedings of the Indiana Academy of Science.

Emys blandingii (Holbrook). Blanding's Turtle.

The first specimens seen were at J-P where a female covered with caked mud and a male with shell clean and shining were walking beside a drainage ditch on April 6. The plastron of the female was badly gnawed by rodents near the center of the humerals, pectorals, and abdominals, and at the vicinity of the hinges. A large male was taken at the Dunes April 8. One specimen, car-killed, was seen at the northwest corner of Marshall County on April 9. A large female was taken just east of Pokagon Park, Steuben County, also on April 9. Fifteen specimens were observed in a ditch at Starke on April 18. In deep water they are alert and difficult to catch. Their yellow necks are very prominent at a distance. Five specimens were taken at J-P in swampy ground. They push along underneath the algae apparently searching for snails. The light yellow mottling of the carapace closely resembles the bubble-filled algal scum. A very clean, clearly marked specimen was taken at the Dunes on April 19. The Dunes specimens are in contrast to the scarred and rusty looking specimens from Starke. A badly mutilated female, with most of the scute tissue destroyed as if by a grass fire, was taken at Starke on April 20. Five females were taken at J-P on April 30. They were in a shallow grassy pond where the grass was dead, but where there were many algae. Most of these had been badly knawed by rodents. To aright themselves individuals of this species pop their long necks back nearly to the center of the carapace, but do not open the mouth, as is the case with the musk and mud turtles. A juvenile was taken at Flint Lake, Valparaiso, on May 6. It measured 3.5x3 cm. and was similar in shape to the juveniles of *Chrysemys*. The tail was two cm. in length and the umbilical scar was present; it was mottled brown above; the plastron was dark brown with narrow yellowish border; a double line or crease showed where the hinge of the plastron was to develop. A male was taken at Starke on May 7. A juvenile was found at J-P, which had been killed by some animal and the head only eaten and the body left on the edge of a ditch together with several more young of other species which had been killed in the same way. Two adult males and three females were taken at the same time and another male at Spectacle Lake five miles north of Valparaiso on May 9. A young specimen taken at J-P on May 11, measured 10.8x7.8 cm. but bore eight or nine growth rings, making it seem to be stunted. Its pattern was similar to that of *T. ornata*, and it had keels on its last three neurals. A female taken on May 15 at Starke had a plastron which appeared to be solid black, but when scaled with the thumb nail the normal colors appeared. My J-P notes for May 17 read: "Still very dry—ponds drying up. Hunted where swamp had been and found five specimens with their backs out of water, burrowing around grass roots, some on land. A three-ring immature had been chewed in two by some animal. One had its plastron severely knawed by some rodent, but not on the edges; the knawing had been done symmetrically over a large area represented by two crescents paralleling the outer posterior edges of the plastron." A specimen was seen at the south edge of Porter County on May 17 and one taken at Starke on May 21. A female, very beautifully marked and in perfect condition, was taken four miles west of Valparaiso on June 4. The choicest of these specimens were presented to the New York Aquarium and the remainder released. All specimens were carefully measured and no gross sexual dimorphism was found. At first it appeared that the male had more hooked front claws and redder eyes than the female, but as the data increased no constant difference, even in size, could be noted.

Terrapene carolina (Linnaeus). Box Turtle.

A very large, high, square female was taken at the Dunes April 12. A large male with each dorsal scute embossed and the primal disc still showing its granular surface was taken on May 8. It measured 16x12.6 cm. A pair was taken five miles west of Valparaiso in open woods near a permanent pond on May 9. The following notes were made on captive individuals between May 14 and 22. The male wedges his long toe nails under rear carapace of female and she clamps her rear plastron so that he cannot escape. He bites at her head and she closes front plastron fastening his lower jaw so that he cannot move; he is now helpless. After ten minutes he gets his lower bill free but cannot get his toes out; finally she bursts forth and tries to dislodge him by scrambling and batting with her front feet; then she gets his toes and lower bill caught again and after five more minutes she comes out and dislodges him. A male rode another male backwards and got his toes pinched in the front plastron of the other. This species was not observed to try to mate with *T. ornata* or *T. triunguis* or any other species. This species was observed to drink several times a day, whereas *T. ornata* drinks about twice a week. A very handsome female, taken at the Dunes, showed about eighteen growth rings even on the plastron. A female taken at the Dunes on May 22 had pink eyes. When looked at through a hand lens the iris resembles colored grains, some white, some red. Two females were taken at the Dunes on June 22. One had a purple iris.

Terrapene ornata (Agassiz). Sand Turtle.

A female was taken at Starke on May 7. My notes read: "Carapace 9.4x7.7 with about sixteen growth rings; a stunted specimen". Later I found that the sand turtle as it is known here is much smaller than *T. ornata* of the western plains. A male taken at J-P on May 9 caused this entry: "Another runt; eye brilliant red; head and face greenish; very active." One small female and two males were taken at J-P on May 10, a pair at Starke on May 31, and a female from J-P on June 10. This female opened her mouth and hissed. This was the only Indiana specimen found which showed any viciousness. In the west this is a rather common trait. It had only three nails on hind feet, but was a typical *T. ornata*. Four males and three females were taken at Starke on June 25. One female measured 50x36 mm. It had both hind feet and some fore toes frozen or burned so badly that they turned black and dropped off. The following observations were made on captive specimens from May 17 to 20: males trying to mate; females very much opposed; a male tried to right a capsized female; a male got hind toes caught in the hind carapace of a female, which reached out and bit at him. When mating the male rises to a vertical or backward position with toes caught in hind shell of female which frequently bites at him.

The fact that Evermann and Clark did not list this species makes it appear possible that it is spreading eastward. Inasmuch as this turtle has been known for forty years from the J-P area, it seems more probable that it was simply overlooked by the Evermann and Clark party even after "a rather careful study by us of that region covering several years." It should be pointed out also that they make no mention of any lizards, although three species appear to be fairly common twenty-five miles west. They state that the Mississippi River formed an impassable barrier between *T. ornata* and *T. carolina*, but this barrier was removed by the building of bridges. In the same paper they again state: "We have then, in the case of *T. ornata*, an invasion eastward . . . by the removal of the barrier of rivers by the building of bridges." This highly ingenious theory may be answered: (1) *T. ornata* has been known from the J-P area for forty years. (2) Who has seen either species marching across a bridge? (3) The parallel rivers flowing through *T. ornata* territory head well outside of their range but did not prove insuperable barriers. (4) They state, "We have heard of perhaps half a dozen others (*T. carolina*) taken or seen within a few miles of the lake." Some of these may well have been *T. ornata*. (5) *T. carolina* does not drown so very easily. It would probably prefer to breast the waves rather than the bridge traffic. Food, climatic, and other ecological conditions may have governed the distribution of these species more than rivers.

Terrapene triunguis (Agassiz).

A female was found in the woods at the Dunes on May 12. It was doubtless an escape or release. There is a mounted specimen in the collection at the University of Valparaiso, and every effort was made to ascertain its source, but to no avail.

Chrysemys picta marginata (Agassiz). Painted turtle.

Specimens were seen or taken as follows: an immature specimen at J-P on April 7, measuring 5.1x4.4 mm.; one dead on highway two miles west of Ligonier, Noble County, April 8; a medium sized female at the Dunes April 8; a large female four miles south of Chesterton and a crushed specimen two miles south of Chesterton on April 9; a specimen without center plastron blotch two miles west of Waterloo, DeKalb County, on April 10; a small specimen at J-P on April 11; six specimens taken in edge of pond and in deeper parts of a drainage ditch on April 18; two specimens from drainage ditches at Starke on April 19; a pair from Starke on April 20. These turtles are covered with red, brown, black, cherry, or mahogany-colored pigment which can be scaled off by the thumb nail when dry. A male and two females were secured from Starke on April 28. As is usually the case, the male is very nervous, active, and vicious. They wave all four feet when picked up instead of retracting as is the custom of the females. A male and a female were taken from Starke on April 30; a male from two miles west of Woodville, Porter County. This specimen was not particularly vicious but snapped when teased. It bore a distinct keel on the first neural. A pair were taken from Flint Lake, Valparaiso, on May 6, a very nervous but not vicious male, and a very old, smooth, and narrow female, measuring 12.1x10.3 cm., from Starke on May 7; two young were found dead on a bank, killed by some animal which devours only the head and fore feet, at J-P on May 9. Two males and two females were taken at the same time and place, a female from Spectacle Lake five miles north of Valparaiso on May 10, and a male from a drainage ditch at Starke on May 11. The male seems to use his front feet and long claws as tactile organs. The male is quicker and more intelligent (?) than the female and is caught more often than his talents warrant, as he is continually wandering into embarrassing cul de sacs, whereas the female sits on a log and tumbles off at the first sign of danger. A female, plain olive green, not decorated as are the specimens from Spectacle Lake, was taken on the dry golf links three miles north of Valparaiso, far from any pond, on May 14; a dead female seven inches long three miles west of Chesterton on May 14; and three females, one vicious, which is rare in this species, from Starke on May 15. Several specimens were seen in a deep drainage ditch on the south edge of Porter County. One was seen picking at something and was easily caught and found to have but one eye. The following is from my notes of May 16: "This is a very dry year—all ponds going dry and crops burning up. This pond, two miles south of Chesterton, contained many turtles and ducks. Walked all over it today and found three recently killed females at the bases of willows growing in the drying pond. The heads and fore feet had been chewed off, but the tail and hind feet had not been touched. There were no tracks showing evidences of a struggle and no tooth marks on the shells. A nearby ditch nearly filled with weeds contained a little water. Here I took a large female which had had her fore feet chewed off and her snout also, but they had healed apparently from the mutilation of a former year. She was very vicious as seems to be the case with any turtle which has been mutilated." Numerous, apparently newly hatched young were taken from Flint Lake, three miles north of Valparaiso, on May 19; about one hundred specimens were seen at Travis Millpond, northwest of Valparaiso on May 20; two specimens were taken from Starke on May 21; a female from six miles south of Chesterton, collected on June 16, had the lower jaw broken, tail off, and vent torn, but all healed, from a prior year's mutilation.

Notes were made on the sexual dimorphism of this species, but Dr. Norman Hartwig has written a thesis on this subject based on a very large number of specimens. It is hoped that it will appear soon.

Amyda spinifer (LeSueur). Soft-shelled Turtle.

Mr. Seward reports this species from the main drainage ditch in J-P.

Appendix

The following list includes specimens observed in J-P from June 21 to December 20, 1933, by Mr. H. B. Seward and identified by means of Hay's "Batrachians and Reptiles of Indiana". *Siren lacertina*, 3;

Ambystoma tigrinum, 8; *A. jeffersonianum*, 3; *Triturus viridescens*, 1; *Bufo americanus*, common; *Hyla versicolor*, 3; *H. crucifer*, 3; *Rana pipiens*, common; *R. cantabrigensis*, 2; *Ophisaurus ventralis*, 6; Lizard, several (probably *C. sexlineatus*); *Storeria dekayi*, 6; *Thamnophis s. sauritus*, common; *T. s. sirtalis*, 20; *Elaphe vulpina*, 3; *Coluber constrictor flaviventris*, 10; *Heterodon contortrix*, 15; *Sistrurus catenatus*, 3; *Clemmys guttata*, common; *Terrapene ornata*, 4.

On page 131 of the thirteenth Annual Report of the Department of Conservation of the State of Indiana the following records for J-P appear: blue racers, 34; prairie snake, 3; cotton mouth moccasin, 1; puff adder, 2; garter snake, 13; hog-nosed snake, 16; water moccasin, 1; grass snake, 9; snapping turtle, 1.

The following has been extracted from the unpublished monthly reports of J-P for 1932: Feb., 1 snapping turtle; June, 5 blue racers; Aug., 4 blue racers; Sept., 1 snapping turtle; Nov., 1 snapping turtle. The same source for 1933 shows: May, 9 blue racers, 3 hog-nosed snakes; June, 11 blue racers; July, 13 snakes; Aug., 2 rattlers; 2 blue racers; Sept., 2 blue racers; Oct., 1 blue racer.

Of course the reptiles listed above were destroyed.

Literature Cited

Blatchley, W. S., 1900. The lakes of northern Indiana. 25th Ann. Rep. Geol. Nat. Res. of Indiana.

————————, 1897. The geology of Lake and Porter counties, Indiana. 22nd Ann. Rep. Geol. Nat. Res. of Indiana.

Evermann, B. W. and Clark, H. W., 1916. The turtles and batrachians of the Lake Maxinkuckee region. Proc. Ind. Acad. of Sci.

————————, 1920. Lake Maxinkuckee. Dept. Conserv. Indiana.

————————, 1930. The painted box turtle in Indiana. Copeia.

Grant, C., 1935. Notes on the spotted turtle in Northern Indiana. Proc. Ind. Acad. Sci. 44:244-247.

————————, ... Secondary sexual differences and notes on the mud turtle *Kinosternon subrubrum* in Northern Indiana. Amer. Midl. Nat. **16**.

Hay, Oliver P., 1891. The batrachians and reptiles of the state of Indiana. 17th Ann. Rep. Geol. Nat. Res. Indiana.

Myers, George S., 1926. A Synopsis for the identification of the amphibians and reptiles of Indiana. Proc. Ind. Acad. Sci.

————————, 1925. Notes on Indiana amphibians and reptiles. Proc. Ind. Acad. Sci.

Necker, W. L., 1935. The dunes of the Chicago region. Bull. Chi. Acad. Sci. **6**.

Schmidt, K. P. and Necker, W. L., 1935. Amphibians and reptiles of the Chicago region. Bull. Chi. Acad. Sci. 5.

Schmidt, K. P., 1930. The Salamanders of the Chicago area and the frogs and toads of the Chicago Area. Leaflets, Field Museum.

Anon., ... 13th Ann. Rep., Dept. Conserv. Indiana.

HERPETOLOGICAL NOTES FROM FORT KNOX, KENTUCKY

CHAPMAN GRANT, San Diego, California

The following observations were made at Fort Knox during C. C. C. mobilization, May 21-24, 1933.

Gyrinophilus porphyriticus (Green). Purple Salamander.

Two adults and two young were found on May 23 under logs in a comparatively high, dry, open forest, all within a diameter of one hundred yards. No other specimens were found in the remaining sixty acres of woods. An injured specimen was taken under a stone at the mouth of a cave. It and another large specimen have mental discs of peculiar structure.

Eurycea lucifuga (Rafinesque). Cave Salamander.

One specimen was taken on May 30 thirty feet within a limestone cave in dim light.

Eumeces fasciatus (Linnaeus). Five-lined Skink.

One of these skinks was taken on May 21 under the bark of a dead oak. Although the weather was warm, the specimen was torpid. The cream-colored body lines were continued in sky blue on the tail, which had a faint bluish sheen underneath. Several other specimens without lines were seen around the cliffs of a stream on May 30.

Sceloporous undulatus (Latreille). Fence Lizard.

Several specimens were seen in trees in a canyon on May 30.

Carphophis amoenae helenae (Kennicott). Worm Snake.

A specimen was taken on May 25 under a board in damp earth in heavy undergrowth. It was brown above and pink beneath.

Lampropeltis calligaster (Say). King Snake.

A male collected on May 24 is characterized as follows: gastrostegs 102, anal entire, 51 paired urostegs; scales, 24, 23, 25, 23, 21, 19; body 87.5, tail, 14 cm.; dorsal spots very much broken and displaying in part two rows instead of saddles, 47 on body and 15 on tail; labials 7—7, 9—9; belly showing fairly regular but faint checkerboard of gray on light ash background; dorsal markings not at all pronounced, consisting of brown spots and saddles narrowly edged with black and then light tan outside the black, also very narrow; background a dark gray with a tinge of olive; belly also tinged with olive; iris copper; dorsal markings touching only 6th. or 7th. row and posteriorly only the 5th.; in the mid-section of the body a third or lower row of spots alternating with the lateral spots, this lowest row including the ends of gastrostegs. The snake was sexually mature and fat. The stomach contained two short-tailed field mice or voles, *Microtus pinetorum auricularis* Bailey, each about 2¾ inches long. This specimen came and stretched out beside me while I was seated on a log in the open woods. He was docile and gentle.

The paucity of specimens in this locality may be due to the denuded character of the soil. No frogs were seen or heard.

The above specimens are now in the collection of Mr. L. M. Klauber, of San Diego, California.

JUNIOR ACADEMY OF SCIENCE

PROGRAM OF FIFTH ANNUAL CONVENTION

Saturday, November 9, 1935

A. M.

9:00-9:30 Display of exhibits from various clubs.
(These exhibits will remain all day)

9:00-9:30 Display of exhibits from various clubs.
Opening address by Howard E. Enders, Purdue University Sponsor of Junior Academy Clubs.
Presentation and acceptance of new members.
Consideration of state constitution.
Election of officers and advisory council member.

12:00 RECESS

P. M.

1:00-1:45 Principal Address: How a Scientist Ought to Work—Dr. Paul Weatherwax, Indiana University.

1:45 The Wabash and Erie Canal—Mary Belle Lackey, Fort Wayne.
Preparation of Skeletal Materials—Melvin Fields, Muncie.
The Value of a High School Science Club from a Student's Viewpoint—Carl Wood, Valparaiso.
Butterflies and Moths—Merrill Eaton, Bloomington.
Termites of Indiana—Wilma Jean Cain, Bloomington.
Experiences in an Insectary—Maurice Campbell, West Lafayette.
Some Fluorescent Materials—Betty Clemons, Anne Holmes and Harry Hadd, Shortridge, Indianapolis.
The Electric Motor—Burton Clay, Bloomington.
The Electric Transformer—Richard Weatherwax, Bloomington.
Some Common Snails—Leon Smith, Bloomington.
What Peps up a Club—M. M. Williams, Bloomington.

MINUTES OF MEETING

The Indiana Junior Academy of Science met at Wabash College, Crawfordsville, Indiana, on Saturday, November 9, 1935, for its fifth annual meeting. Merrill V. Eaton, of Bloomington, presided.

Fourteen active clubs were represented: Columbia City, Lowell, Muncie, Cambridge City, Tipton, Montmorenci, West Lafayette, Coesse, Shortridge and Crispus Attucks of Indianapolis, Crawfordsville, Bloomington, Valparaiso, and North Madison.

Dr. Howard E. Enders, of Purdue University, gave the opening talk, reviewing the meetings of the Indiana Junior Academy of Science for the last three years. He stated that this organization is affiliated with the American Association for the Advancement of Science. He briefly sketched the projects which had been completed by the Science Clubs in Indiana and presented a map on which he had placed colored pins showing the locations of the clubs throughout the state. The color of the pins represented the clubs as active, affiliated but inactive, and in process of organization. He expressed the desire that the blue and white pins, representing the last two, would all in time be changed to red pins, marking them active, by next year.

The discussion of the constitution for the Junior Academy of Science was resumed from last year, but action was deferred. It was made clear that the Junior Academy of Science is merely a branch of the Senior Academy and that members of the Senior Academy who make up the Advisory Council will aid in the decision upon all important matters for the junior organization.

Election of members to the Advisory Council followed: Mr. F. J. Breeze of the Geography Council, North Side High School, Fort Wayne, succeeds M. M. Williams, of Bloomington, for the five-year period, and Mr. Wade, of Crispus Attucks High School, Indianapolis, fills the unexpired term of Miss Edna Banta, formerly of Hilltop Nature Study Club of North Madison. Miss Banta resigned her position because she is not now teaching in high school.

The following officers were elected to serve at the 1936 meeting: Merrill V. Eaton, of Bloomington, president; Carl Oldham, of Oakland City, vice-president; Ruth Heitz, of North Madison, secretary; and Margaret Nell Follick, of Montmorenci, treasurer.

Many interesting exhibits of projects were arranged by the various clubs. The clubs were complimented upon the success of their projects. Dr. Enders announced that the exhibits represented much work upon the part of the club membership or of individuals.

A list of the exhibits follows:

Bloomington.—Butterfly collection, snail collection, termite activities, Tesla coil, motor.

Crawfordsville.—Mounted birds and mammals, weed seeds, weeds, rocks, leaf collection, snakes (live specimens), insect collection.

Muncie (Blaine Jr. H. S.).—32 Skeletons.

Gary (Lew Wallace H. S.).—Insect collections, seed collection.

Valparaiso.—Volt-ohm-milliometer, bolometer, electric safe lock combination, radio set (hand made), motor (hand made).

West Lafayette.—Three-tube regenerative radio, skeleton of turtle, skulls of rodents, camera and pictures, mosquitoes and rat-tailed maggots, salamander, twig collection, model airplanes, praying mantis and egg case.

Indianapolis (Shortridge).—Fluorescent materials (loaned by Walter C. Geisler and Chemistry Department):

Fluorite with celestite, willemite, hyalite, moss agate, antimite, curtisite, wernerite, fluorspar, Amazon stone, pink tourmaline, spirel (synthetic), calcite, topaz, opals.

These specimens, when subjected to ultra violet radiation reflected (from an argon bulb), fluoresce and give off a variety of colors, the color depending upon the material and in some cases the locality from which it came.

Dr. Paul Weatherwax, of Indiana University, gave the principal address of the afternoon session. He told "How Scientists Work". He made it clear that a scientist must first use observation, must keep a record of his observations, and must be influenced to some extent by what scientists have found out in the past. He showed by some illustrations the dangers in experimenting with gases about which one knows nothing. The same would be true in any other phase of science.

Many instructive talks were given by young scientists of various clubs, as indicated on the program. Some of the talks were illustrated with slides.

The total attendance exceeded one hundred and fifty persons.

Adjourned about 3 P. M.

Ruth M. Heitz,
Secretary of the 1935 Session.

JUNIOR ACADEMY OF SCIENCE CLUBS IN ORDER OF AFFILIATION

1931-1932 *Hilltop Nature Study Club, North Madison.
*Sciemus Club, Valparaiso, C. O. Pauley.
*General Science Club, Bloomington, M. M. Williams.
*Audubon Society, Crawfordsville, Emmett Stout.
*Biology Club, Crispus Attucks H. S., Indianapolis, (Miss) C. E. Ransom.
*Chemistry Club, Shortridge, Indianapolis, Lois E. Martin.
*Science Club, Union City, W. H. Miner.
*Nature Study Club, Arsenal Technical, Indianapolis, C. F. Cox.
*Whitley County, (1) Washington Center Hiking and Nature Lore Club, Virgil Lafuse; (2) Coesse's Jolly Hiking and Nature Club, Charles Luther.
1932 Geography Council, North Side H. S., Fort Wayne, Fred J. Breeze.
1933 Science Club, West Lafayette, Anna Inskeep.
Junior Science Club, Tipton, Wm. D. Hiatt.
Junior Academy of Science, Montmorenci, I. W. Vance.
1934 Tri-Science Club, Cambridge City, J. L. Bozarth.
Science Club, Blaine, Jr. H. S., Muncie, Robert Cooper.
1935 [1]Science Club, Lowell, R. J. Brannock.
[1]Junior Academy of Science Club, Lew Wallace H. S., Gary, Lola Lemon.
[1]Science Club, Paoli, O. R. Whitlock.
[1]Edison Club, Roosevetl H. S., East Chicago, Harry Apostle.

---

*Charter members. [1]Organized since the meeting of 1935.

MEMBERS

The following list of members supplements the complete list published in Volume 44 of the Proceedings. Only new members and those whose addresses have been changed are listed here. The address given in each case is the latest on file in the office of the Secretary; if address is known to be incorrect, it is followed by (I).

Allisbaugh, Howard C., Eli Lilly Co., Indianapolis
Arcadi, Vittorio G., 814 North Broadway, Baltimore, Maryland
Amos, John Madison, 2416 E. Main St., Lafayette
Babcock, Wm. C. (Jr.), Rensselaer
Barker, James F., Purdue University, Lafayette
Barnett, Richard, Route 1, Box 1, Danville
Beard, Charles N., Oaktown
Bennett, Paul Esmond, Dillsboro
Bottorff, Edmond, 1638 Franklin St., Columbus
Brown, Harry E., 121 Chauncey, W. Lafayette
Bruce, Robert, 616 West Pike St., Crawfordsville
Buchanan, Charles, Marott Hotel, Indianapolis
Butchart, John Harvey, 4333 Cornelius, Indianapolis
Cain, Stanley, Dept. Botany, University Tennessee, Knoxville Tenn.
Call, Herbert F., 817 Hume Mansur Bldg., Indianapolis
Campbell, Guy, Lexington
Campbell, Marion S., 29 N. Hawthorn Lane, Indianapolis
Carr, Arthur, 1927 N. New Jersey St., Indianapolis
Conklin, Edmund S., Dept. Psychology, Indiana University, Bloomington
Cope, Alfred B., Evansville College, Evansville
Demaree, Delzie, John Bryan State Park, Yellow Springs, Ohio
DeVries, Thomas, Chemistry Dept., Purdue University, W. Lafayette
Dickerson, L. L., Indianapolis Public Library, Indianapolis
Dimmitt, Roy, 710 Chelsea Rd., W. Lafayette
Eaton, Merrill T., Indiana University, Bloomington
Eggleston, Sister Mary Frederick, St. Mary's College, Notre Dame
Fidlar, Orville F., R. 1, Vincennes
Fine, Mary Ellen, 1075 Grant Ave., Crawfordsville
Fitch, Harry N., 404 Beechwood Ave., Muncie
Fix, Gordon F., 440 E. Second St., Bloomington
Forsyth, Owen, 2520 Cass St., Fort Wayne
Frick, Charles H., Valparaiso University, Valparaiso
Gierut, Reverend Joseph A., 124 Lyons Hall, Notre Dame
Grant, Chapman, 2970 6th Ave., San Diego, California
Greene, Frank C., Box 138, Rolla, Missouri
Gutermuth, Clinton, 3025 N. Meridian St., Indianapolis
Hall, Fred T., 1215 Danville Ave., Crawfordsville
Hall, O. F., 829 N. Salisbury, W. Lafayette
Harrar, Norman J., Franklin College, Franklin
Hassmer, Joseph, Lawrencebury
Headlee, W. H., Biology Dept., Purdue University, Lafayette
Hendricks, Thomas, 2518 Broadway, Indianapolis
Hennel, Cora B., 410 S. Park Ave., Bloomington
Hertzler, Silas, 110 W. Lafayette St., Goshen

Hinman, Jack J., Jr., Box 363, University of Iowa, Iowa City, Iowa
Hitz, Benjamin D., 120 S. Alabama St., Indianapolis
Horton, George W., Crawfordsville
Howie, Hillis L., 4443 Guilford Ave., Indianapolis
Huddle, John W., University of N. Carolina, Chapel Hill, North Carolina
Hunt, Raymond S., Box 149, Mt. Pleasant, Michigan
Hurst, Lawrence, 320 N. Talley Ave., Muncie
Hurwitz, Joseph, 417 Waldron, W. Lafayette
Hydle, Lars L., Ball State Teachers College, Muncie
Jack, Homer A., 290 Crosman Terrace, Rochester, N. Y.
Johnson, Benjamin, Petersbury, R. R. 5
Jones, Martha J., 1400 S. 11½ St., Terre Haute
Kanning, Eugene W., Department Chemistry, Indiana University, Bloomington
Kemper, Mary E., Grant Hospital, Chicago, Ill.
Kendall, William R., 302 Lafayette St., Valparaiso
Kenoyer, E. Fay, 3216 Ralston Ave., Indianapolis
Killian, Donald Bernard, Box 203, Notre Dame
King, Samuel M., Taylor University, Upland
Kline, Reverend James E., Notre Dame
Koch, Norma, 2222 N. Delaware, Indianapolis
LaHue, Delmon William, 705 N. Meridian, W. Lafayette
Lancaster, Robert F., Calhoun St., South Whitley
Landon, Hugh McK., Fletcher Trust Co., Indianapolis
Lindberg, Carl F., Valparaiso University, Valparaiso
Linville, Ralph B., Baxter Hall, Illinois College, Jacksonville, Illinois
Liston, Jesse G., R. R. 2, Jasonville
Loew, Fred A., 916 Hime St., Huntington
Luttman, Joseph F., University of Notre Dame, Notre Dame
McConaha, Marjorie, State University of Iowa, Dept. Botany, Iowa City, Iowa
McCormick, Clyde T., 1422 Monon Dr., Bloomington
Middleton, Warren C., 401 E. Seminary, Greencastle
Miller, Mrs. Edwin (Formerly Judith Fillingham) Zoology 378, Louisiana State University, Baton Rouge, Louisiana
Miller, Harold, New Albany R. R. 1 (I)
Miner, Dewey H., 440 W. 35th Street, Kansas City, Missouri
Mitten, Arthur G., R. F. D. 1, Goodland
Morgan, Leonord C., 5440 Kenwood Ave., Indianapolis
Mozingo, Ralph V., Chemistry Dept., University Wisconsin, Madison, Wis.
Murray, Leo T., 403 South College Ave., Muncie
Noble, Thomas B., Jr., R. R. 17, Box 187, Indianapolis
Noland, Stephen C., Indianapolis News, Indianapolis
Norcross, Gerald W., 718 Weghorst St., Indianapolis
Noss, Theodore K., Dept. Education, Purdue University, Lafayette
Noyes, Harry A., Applied Sugar Laboratory, 711 Wall St., N. Y. City
O'Brien, Cornelius, 455 Ridge Ave., Lawrencebury
O'Shea, Harriet, Women's Personnel Service, Purdue University, Lafayette
Oswald, Jack W., 424 S. Sixth St., La Grange, Illinois

Payne, Clarke B., Winchester
Peters, Gustavus A., Indiana University, School Medicine, Indianapolis
Rasmussen, Rasmus G., Rasmussen Court, New Albany
Reavis, Tolbert, 3962 Ruckle St., Indianapolis
Remmers, Hermann H., Purdue University, Lafayette
Rich, Ronald E., 402 East Howard St., South Bend
Roff, Merrill F., Department Psychology, Indiana University, Bloomington
Russell, Merwyn A., 224 N. Harrison St., Rushville
Scally, Lena, Box 227, Elkhart
Scarf, Robert C., Ball State Teachers College, Muncie
Schilling, Clarence G., Purdue University, Lafayette
Scott, Paul J., 811 S. Grant, Indianapolis
Seybert, John E., 4842 Kenwood Ave., Indianapolis
Shoemaker, Hust H., Chicago University, Dept. Zoology, Chicago
Shriner, Walter Owen, 2525 N. Ninth St., Terre Haute
Smith, Arthur L., Central H. S., South Bend.
Spahr, John, 5657 Meriam Rd., Frankfort, Philadelphia
Stillson, Blanche, 4245 N. Meridian, Indianapolis
Stork, Mary Louise, 310 Washington Ave., Evansville
Tallman, Arthur Wince, Johnstown, Ohio
Tasker, Roy C., Bucknell Univ., Wilkes-Barre, Pennsylvania
Thompson, Wallen H., R. R. 3, Box 234, Madison
Torrey, Theodore W., Zoology Department, Indiana University, Bloomington
Trimble, Otis C., Department Education, Purdue University, Lafayette
Ulman, P. T., 404 State Library, Indianapolis
Vandebark, James H., Martinsville
Van Osdol, ————, 217 W. Third St., Rushville
Verda, Sister Mary, St. Mary's College, Notre Dame
Vreeland, Francis McLennon, 606 E. Anderson, Greencastle
Wade, George W., 1318 Cornell Ave., Indianapolis
Wallace, John H., 3840 N. Capitol, Indianapolis
Warnock, C. O., 4324 Park Ave., Indianapolis
Washburn, Harry A., Waldron
Weer, Paul W., 1808 N. Delaware, Indianapolis
Welch, Winona, 209 E. Seminary, Greencastle
Wells, Milo, Physics Dept., Indiana University, Bloomington
Whitelock, Orace R., Paoli
Wilhite, Ida B., Butler University, Indianapolis
Wilkins, LaRoy W., University of Notre Dame, Notre Dame
Williams, John E., 187 N. 5th Street, Middletown
Young, Charles A., Box 43, Notre Dame
Zumstein R. R., 210 Waldron St., W. Lafayette

JUNIOR ACADEMY MEMBERS

Gary—The Biology Club of Lew Wallace H. S., 45th and Madison, Gary
Lowell—Science Club, Lowell H. S., Lowell
New Albany Junior Academy of Science, E. Spring St., New Albany
Paoli Science Club, Paoli H. S., Paoli
Tipton—Science Club of Tipton H. S., Tipton

INDEX

Page

Academy Foundation, Report on . . . 11
Acetic Acid, Determination of . . . 157
Algae: of Indiana, 99; of Lower Wabash Valley . . . 61
Alkyl Bromides, Preparation of . . . 139
Allen, F. J. (with L. A. Test), Paper by . . . 166
Allisbaugh, H. C. and L. C. Morgan, Paper by . . . 131
American Association for the Advancement of Science, Report of Committee on . . . 17
American Indian, Origin of . . . 48
Amphibia: of Indiana, 323; of Putnam County . . . 287
Aquatic Habitat . . . 26
Archeological Survey, Report of Committee on . . . 11
Archeology: Papers on, 36-59; Program of Section on, 35; Report of Special Committee on . . . 17
Artifacts, Classification of . . . 36
Attitudes, the Genetics of . . . 241
Auditing Committee, Report of . . . 12
Bacteriology: Papers on, 110-173; (with chemistry), Program of Section on . . . 109
Baker, E. G. S., Paper by . . . 251
Banta, Edna, Paper by . . . 89
Biological Survey, Report of Committee on . . . 13
Birds of Indiana . . . 269
Bishop, C. A. (with M. W. Lyon), Paper by . . . 253
Black, E. G. (with A. E. Reynolds), Paper by . . . 287
Black, G. A. and Paul Weer, Paper by . . . 36
Blanchard, W. M., Paper by . . . 124
Blue River Valley, Fossils of . . . 64
Bonding Committee, Report of . . . 13
Boreal Plant Relics in Indiana . . . 78
Botany: Papers on, 61-108; Program of the Section on . . . 60
Bradt, W. E. (with Fred O. Gibson), Paper by . . . 157
Briscoe, H. T. (with F. E. Dolian), Paper by . . . 110
Britton, M. E. and B. H. Smith, Paper by . . . 61
Buhl, Carl A., Memorial to . . . 25
Busteed, R. C., Paper by . . . 22
Butler, A. W., Papers by . . . 20, 269
Butterflies of Indiana . . . 273
Bythoscopinae of Indiana . . . 310
Chemical Education in Indiana, History of . . . 166
Chemistry and Bacteriology: Papers on, 110-173; Program of Section on . . . 109
Clark County, Myxomycetes of . . . 69
Classification of Artifacts . . . 36
Climate of Indiana . . . 183

PAGE

Committee Reports: on A. A. A. S., 17; on Archeological Survey, 11; on Archeology, 11, 17; Auditing, 12; on Biological Survey, 13; Bonding, 13; on Junior Academy, 17; on Library, 14; on Mathematics, 18; on Membership, 15; on Nominations, 17, 19; on Program, 15; on Publication of Proceedings, 15; on Psychology, 18; on Relation of Academy to State, 15; on Research, 15; on Resolutions 19
Committees, Lists of 5, 6
Compass, Magnetic 212
Council Meeting, Minutes of 8
Crystal Structure of Solidified Gases 222
Darwin, Charles, the Psychology of 237
Davis, J. J., Paper by 257
Deay, H. O. and G. E. Gould, Paper by 305
Degering, Ed. F. (with R. N. Goshorn), Paper by 139
Divisional Chairmen, List of 19
Dolian, F. E. and H. T. Briscoe, Paper by 110
Dragonfly, Nymphal Stages of 315
Du Claux Analysis 157
Edington, Will, Paper by 206
Editor, Report of 13
Executive Committee, Minutes of 11
Fidlar, M. M., Paper by 175
Fischer Reaction, Preparation of Indoles by 145
Fleischer, I. F. and R. J. Hartman, Paper by 161
Foote, N. (with J. L. Riebsomer), Paper by 116
Formic Acid, Determination of 157
Fossils of Blue River Valley, Henry County 64
Foundation, Academy, Report on 11
Fungi 94, 102
Fungous Contamination of Shaving Cream 102
Gastric Mucin, Enhancement of Bacterial Virulence by 133
General Session, Minutes of 19
Geology and Geography: Papers on, 175-204; Program of the Section on 174
Gibson, Fred O. and W. E. Bradt, Paper by 157
Glenn, Oliver E., Paper by 229
Glue, Effect of Sodium Ortho Phenyl Phenate on 161
Gomphaeschna, Nymphal Stages of 315
Goshorn, R. H. and Ed. F. Degering, Paper by 139
Gould, G. E. (with H. O. Deay), Paper by 305
Grant, Chapman, Paper by 323, 334
Grasses of Indiana 103
Gray, Wm. D., Papers by 69, 74
Hall Effect in a Circular Bismuth Plate 214
Hall, Fred T., Paper by 273
Halo Phenomenon 229
Hardness, Meaning and Measurement of 217
Hartman, R. J. (with I. F. Fleischer), Paper by 161
Hemiptera of Indiana 305
Henderson, Ruth, and Others, Paper by 131

PAGE
Henry County, Fossils of 64
Herpetological Notes: from Indiana, 328; from Kentucky 334
Heigel, A. J. and E. W. Kenefake, Paper by 220
History of Chemical Education in Indiana 166
Indian, Origin and Antiquity of 48
Indiana: Amphibians of, 323; Climate of, 183; Herpetology of, 323; Insects of, 257, 305, 310; Plants of, 61, 64, 69, 77, 78, 89, 99, 103; Reptiles of 325
Indole Series 145
Insects of Indiana 257, 305, 310
Jamieson, W. A. (with others), Paper by 131
Jasper County, Vascular Plants of 77
Jefferson County, Plants of 89
Jenkins, O. P., Memorial to 20
Julian, Percy L. and Josef Pikl, Paper by 145
Junior Academy: List of Clubs, 337; Program of Meeting, 335; Report of Committee on 17
Kenefake, E. W. (with A. J. Hiegel), Paper by 220
Kennedy, C. H., Paper by 315
Kentucky, Herpetology of 334
Kukui Nuts, Oil of 116
La Hue, Delmon W., Paper by 310
Legislation to Fix Value of *pi* 206
Library, Committee on 14
Lilly, Eli, Paper by 48
Ludwig, C. A., Paper by 108
Lyon, M. W. and C. A. Bishop, Paper by 253
Lyons, R. E. (with F. M. Miller), Paper by 151
Magnetic Compass 212
Mahin, E. G., Paper by 217
Mathematics: Paper on, 206; Program of Section on, 205; Report of Committee on 18
Members, List of 338
Membership, Report of Committee on 15
Memorials 20-25
Miller, F. M. and R. E. Lyons, Paper by 151
Minutes: of Council Meeting, 8; of Executive Committee, 11; of General Session, 19; of Spring Meeting 8
Miner, D. H. (with Will Scott), Paper by 275
Morgan, L. C. (with H. C. Allisbaugh), Paper by 131
Mucin, Gastric, Enhancement of Bacterial Virulence by 133
Myxomycetes of Clark County 69
Necrology 9
Nominating Committee, Report of 17, 19
Non-aqueous Solutions, Refractive Indices of 110
Officers for 1935 5
Oil of Kukui Nuts 116
Optical Principles of the Halo Phenomenon 229
Oxygen, Determination of in Air 120
Pasteurization of Soil 94

PAGE

Pauley, C. O., Paper by 120

Pennaria, Spawning of 251

Petersen, L. H., Paper by 214

Photoperiodicity in Spawning of Pennaria 251

Physics: Papers on, 212-235; Program of Section on 211

Pi, Attempt to Fix Value by Legislation 206

Pikl, Josef (with Percy L. Julian), Paper by 145

Plasmodium of Stemonitis 74

Plasterer, E. G., Paper by 212

Porter, C. L. and John H. Porter, Paper by 102

Potzger, J. E., Papers by 64, 103

Powell, H. M. (with others), Paper by 131

Prairie Rattlesnake, Bite of 253

Presidential Address 26

Program Committee, Report of 15

Program of Winter Meeting 9

Programs of Sectional Meetings: Archeology, 35; Botany, 60; Chemistry and Bacteriology, 109; Geology and Geography, 174; Mathematics, 205; Physics, 211; Psychology, 236; Zoology 249

Psychology: of Charles Darwin, 237; Papers on, 237-248; Program of the Section on, 236; Report of Committee on, 18; Two-Fold Relation of 245

Publication of Proceedings, Report of Committee on 15

Putnam County, Salamanders of 287

Rattlesnake, Bite of 253

Refractive Indices of Non-aqueous Solutions 110

Relation of Academy to State, Report of Committee on 15

Remmers, H. H., Paper by 241

Reptilia of Indiana 325

Research, Report of Committee on 15

Resolutions, Report of Committee on 19

Reynolds, A. E. and E. G. Black, Paper by 287

Rhopalocera in Indiana 273

Riebsomer, J. L. and N. Foote, Paper by 116

Scott, Will, Papers by 26, 275

Sectional Chairmen, Announcement of 19

Sectional Programs: Archeology, 35; Botany, 60; Chemistry and Bacteriology, 109; Geology and Geography, 174; Physics, 211; Psychology, 236; Zoology 249

Sedimentation: in Tippecanoe Lake, 275; in Winona Lake 275, 295

Seedling of Sunflower 108

Shaving Cream, A Fungous Contamination of 102

Sister Mary Frederick, Paper by 237

Sister Mary Verda, Paper by 245

Sistrurus, Bite of 253

Smith, B. H. (with M. E. Britton), Paper by 61

Snakebite 253

Sodium Ortho Phenyl Phenate, effect of on Glue 161

Soil Pasteurization 94

Solidified Gases, Crystalline Structure of 222

PAGE
Spawning of Pennaria 251
Spring Meeting, Minutes of 8
Stemonitis, Plasmodium of 74
Sunflower, Seedling Variation of 108
Test, L. A. and F. J. Allen, Paper by 166
Tippecanoe Lake, Sedimentation in 275
Treasurer, Report of 16
Tryptophane: Chemistry of, 151; Determination of, 151; in Phytochemical Processes 124
Unipolar Magnetic Compass 212
Vaccinia Virus, Cultivation of 131
Van Hook, J. M., Memorial to 22
Virus, Cultivation of 131
Visher, S. S., Paper by 183
Vultures in Indiana 269
Wabash Valley: Algae of, 61; Geology of at Vincennes 175
Washer, F. E., Paper by 222
Weer, Paul (with G. A. Black), Paper by 36
Welch, Winona H., Papers by 77, 78
Weston Photronic Cell, Response to X-rays 220
Wilson, Ira T., Paper by 295
Winona Lake: Map, Facing p. 295; Sedimentation in 275, 295
Winter Meeting, Program of 9
X-rays, Response of Photronic Cell to 220
Zoology: Papers on, 251-334; Program of Section on 249
Zumstein, R. B., Paper by 94